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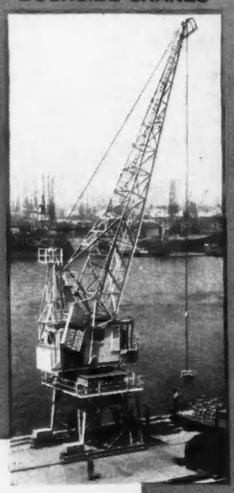

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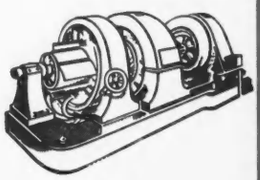
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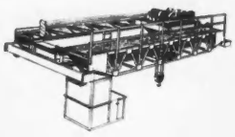
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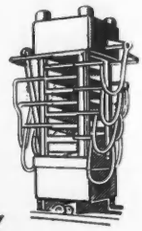

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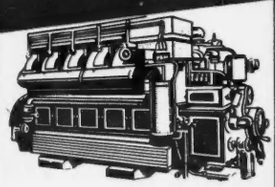
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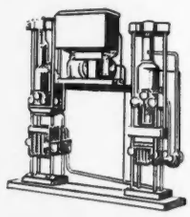
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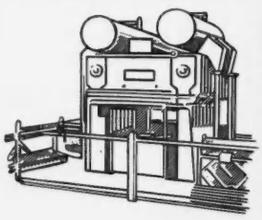
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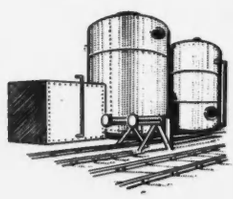
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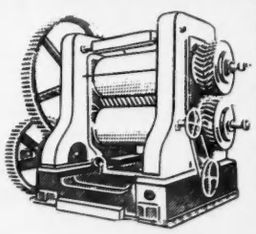
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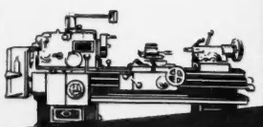
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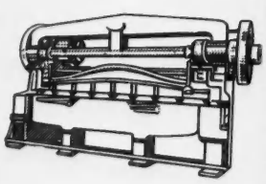
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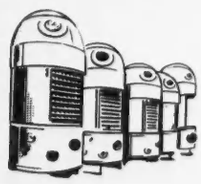

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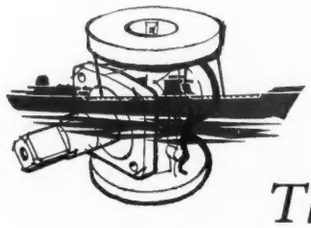

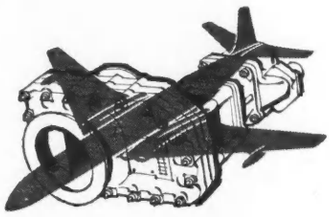

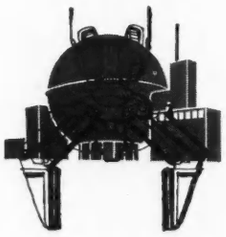

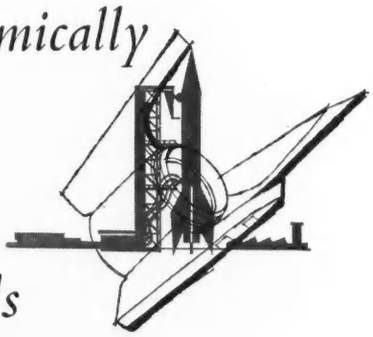

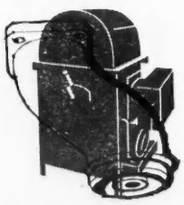

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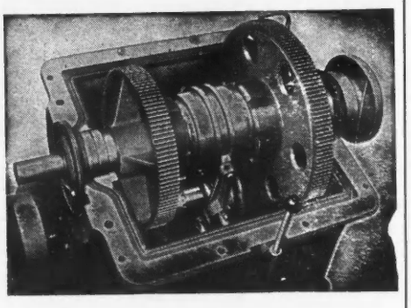

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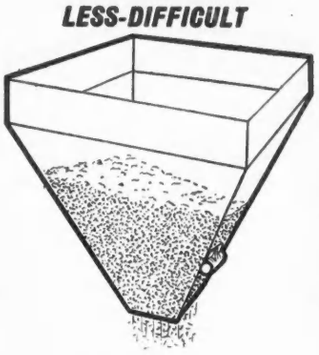
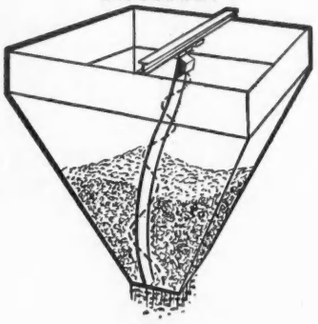


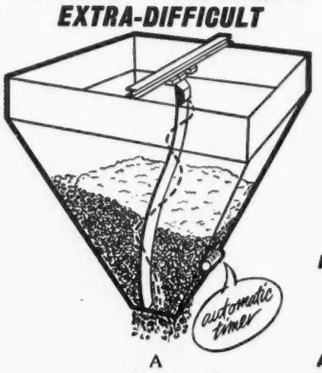
The installation of an external vibrator to a steel hopper.

DIFFICULT



The vibrating reed for application where external vibration is impractical due to structural or other difficulties and if the bunker is made of concrete.

EXTRA-DIFFICULT



A combination of internal and external bunker vibration. Where the external vibrator is timed for 'on and off', the vibration frequency, on slowing down, goes through the natural resonance of the bunker, irrespective of load material contained.

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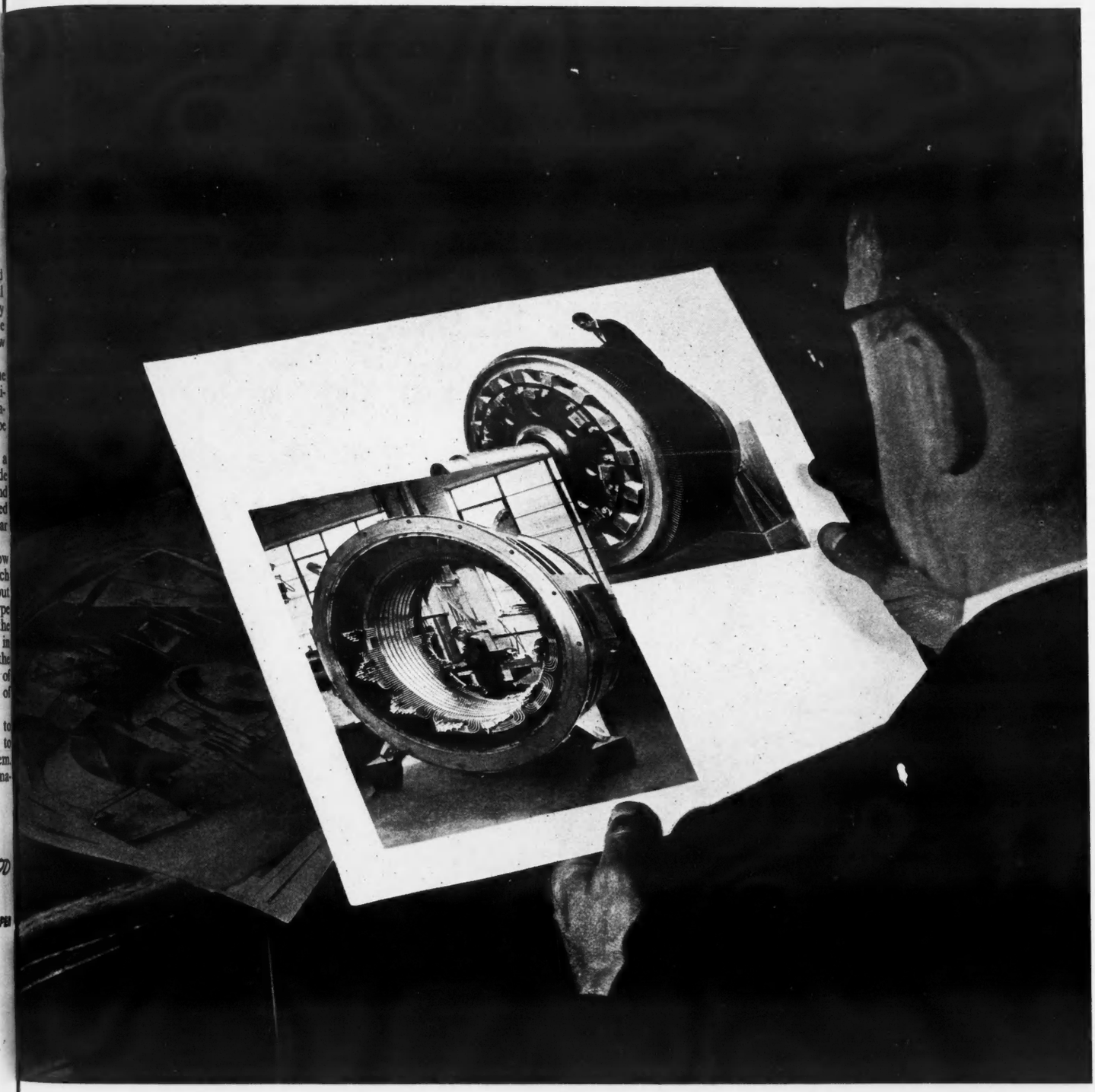

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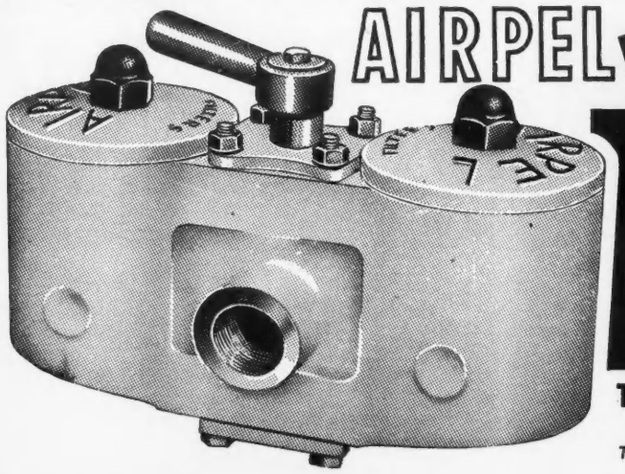

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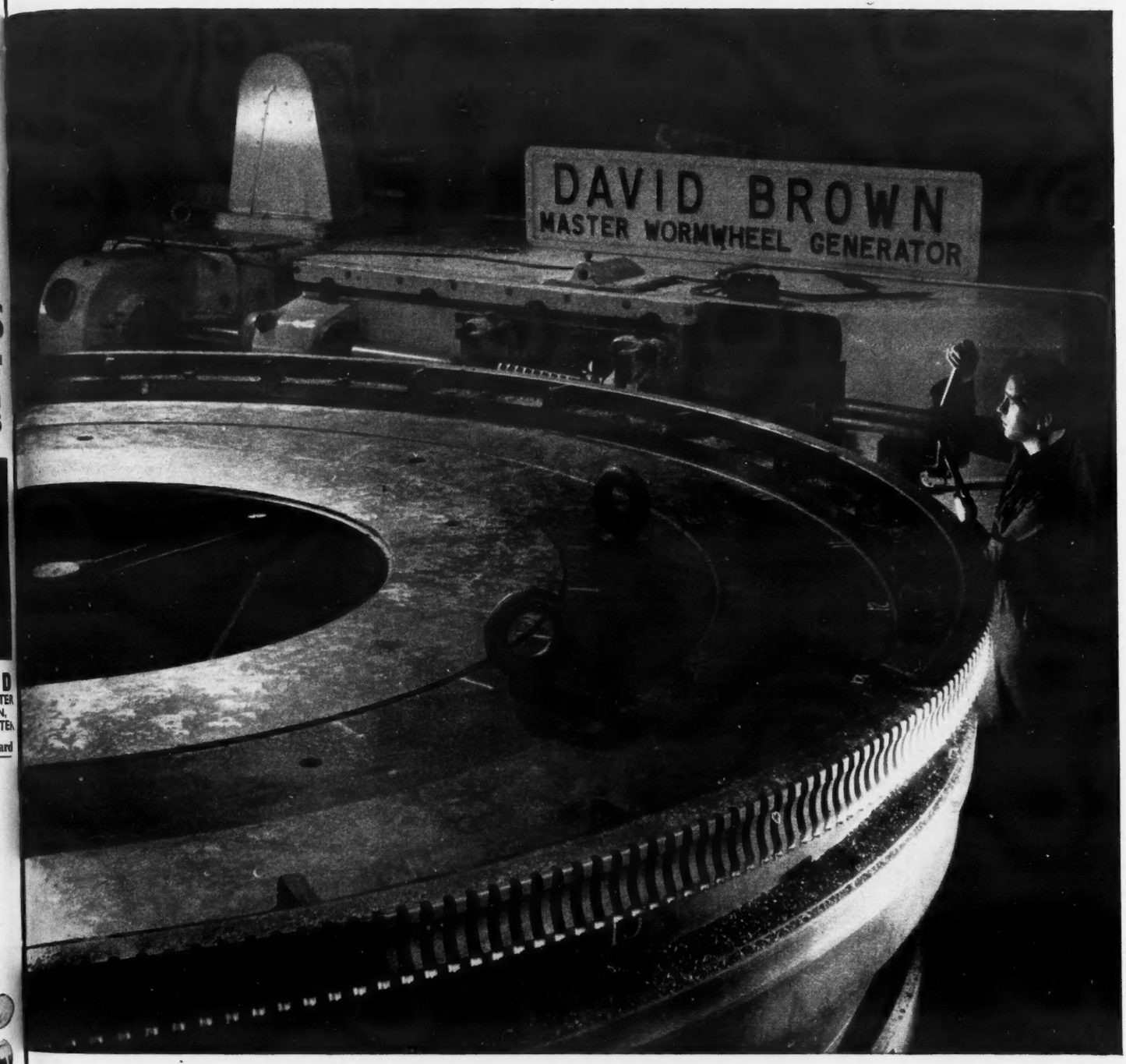

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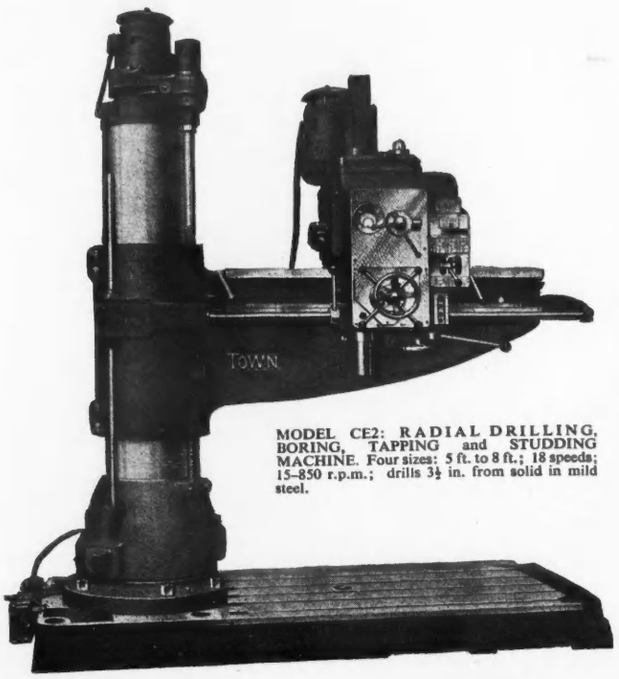
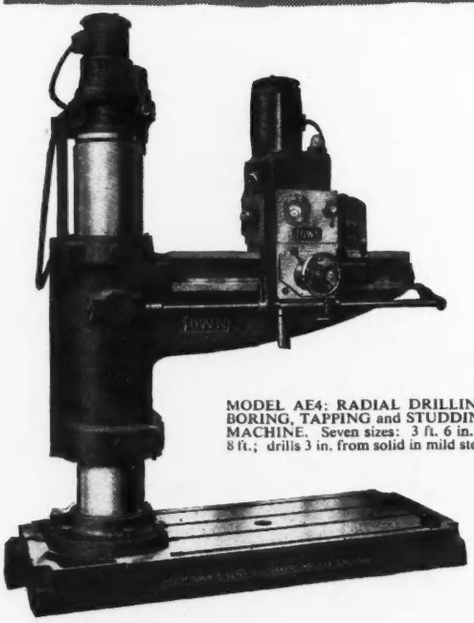
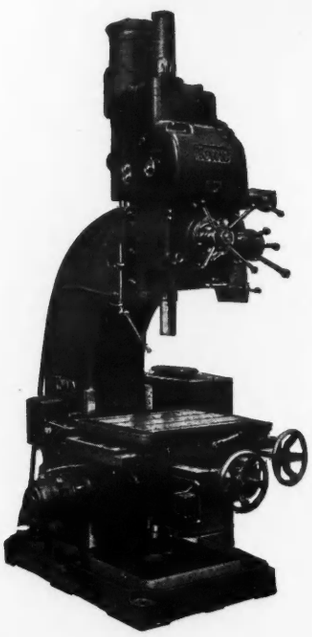


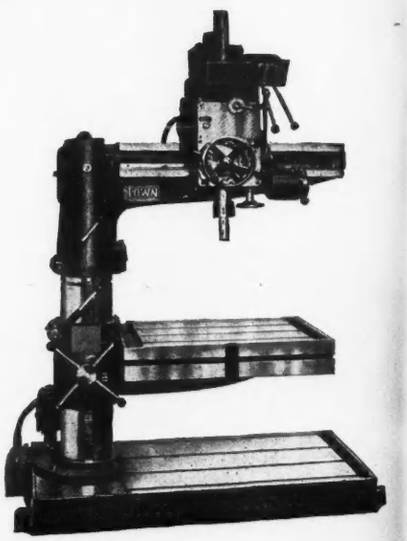
MODEL CE2: RADIAL DRILLING, BORING, TAPPING and STUDDING MACHINE. Four sizes: 5 ft. to 8 ft.; 18 speeds; 15–850 r.p.m.; drills 3½ in. from solid in mild steel.



MODEL AE4: RADIAL DRILLING, BORING, TAPPING and STUDDING MACHINE. Seven sizes: 3 ft. 6 in. to 8 ft.; drills 3 in. from solid in mild steel.



MODEL AE2: VERTICAL DRILLING MACHINE (heavy-duty model). Two sizes: 36 in. and 42 in.; drills 3½ in. from solid in mild steel.



MODEL AE5: RADIAL DRILLING, TAPPING and STUDDING MACHINE. 42 in.; drills 1¾ in. from solid in mild steel or 1½ in. in cast iron.

MODELS EG4 and EG8: RADIAL DRILLING GIRDER MACHINES. Each model in five sizes: 4 ft. to 8 ft.; 4 speeds; 160–600 r.p.m. (EG4), 8 speeds; 20–500 r.p.m. (EG8), drills up to 2 in. from solid in mild steel. Also made with single speed.

OTHER MACHINES IN THE RANGE

are detailed in a folder 'GO TO TOWN' which is available on request. Variations on the standard range can be undertaken, and examples are also illustrated in the folder.

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ESTABLISHED · 1903

HALIFAX · YORKS

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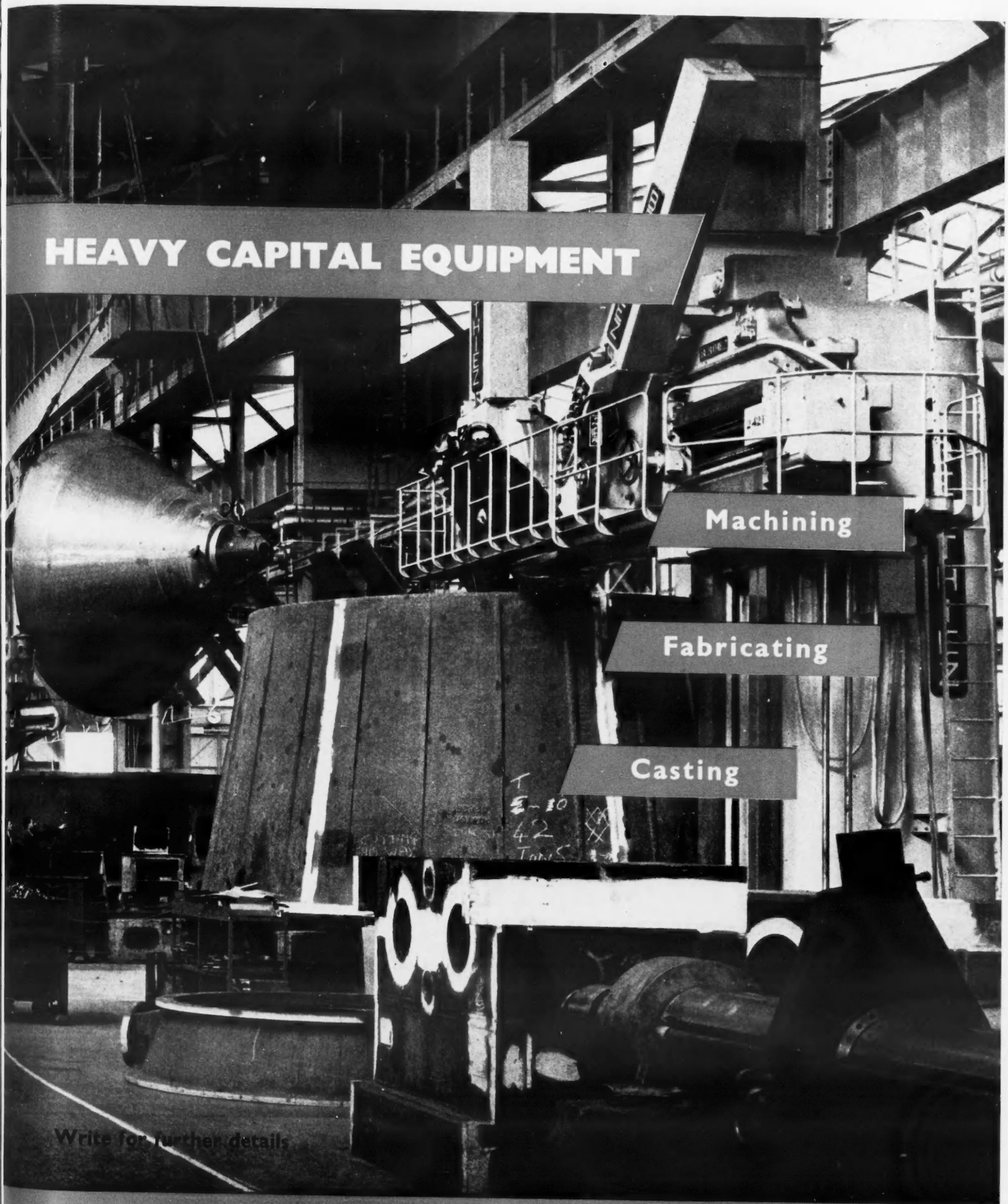

ASHMORE, BENSON, PEASE & COMPANY LIMITED
STOCKTON-ON-TEES AND LONDON
MEMBER OF THE
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Q What is a Safe Breaker?

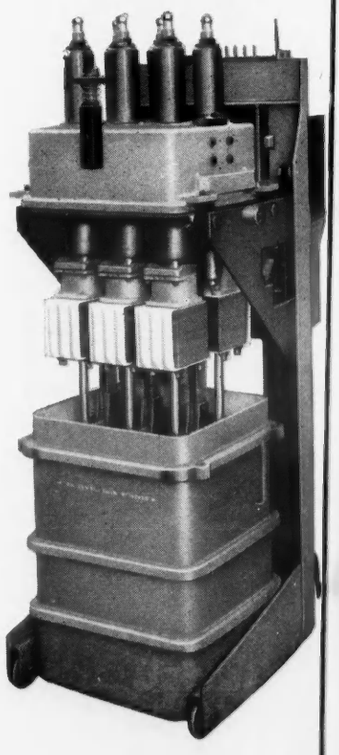
A If you are worried about the payroll and your mind jumps to the kind of gentleman shown above — ask a policeman.

If you are thinking of circuit-breakers—the J. & P. Type PDB arc-control oil circuit-breaker is undoubtedly the right answer.

This breaker achieved a remarkable performance during tests and, although designed for the more usual distribution duties of 250 MVA at 11 kV, it is certified for a breaking capacity of 350 MVA at 11 kV — a margin every engineer will appreciate is safe.

The TYPE PDB OIL CIRCUIT-BREAKER

- ★ **has certified breaking capacities of**
  350 MVA at 11 kV
  250 MVA at 6·6 kV
  150 MVA at 3·3 kV
- ★ **has current ratings of 400A, 800A and 1200A.**
- ★ **is designed for use in standard metalclad gear only 1′ 9½″ wide.**
- ★ **is available at very competitive prices.**
- ★ **has had each phase successfully tested to earth separately at full power.**
- ★ **has the arc confined to the arc-control device at all short-circuit ratings, even down to 2½% of full rating.**
- ★ **has porcelain bushings on the 400A and 800A unit even for 350 MVA duty.**



When thinking of SAFE CIRCUIT-BREAKERS — ask J. & P.!

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CHARLTON, LONDON, S.E.7

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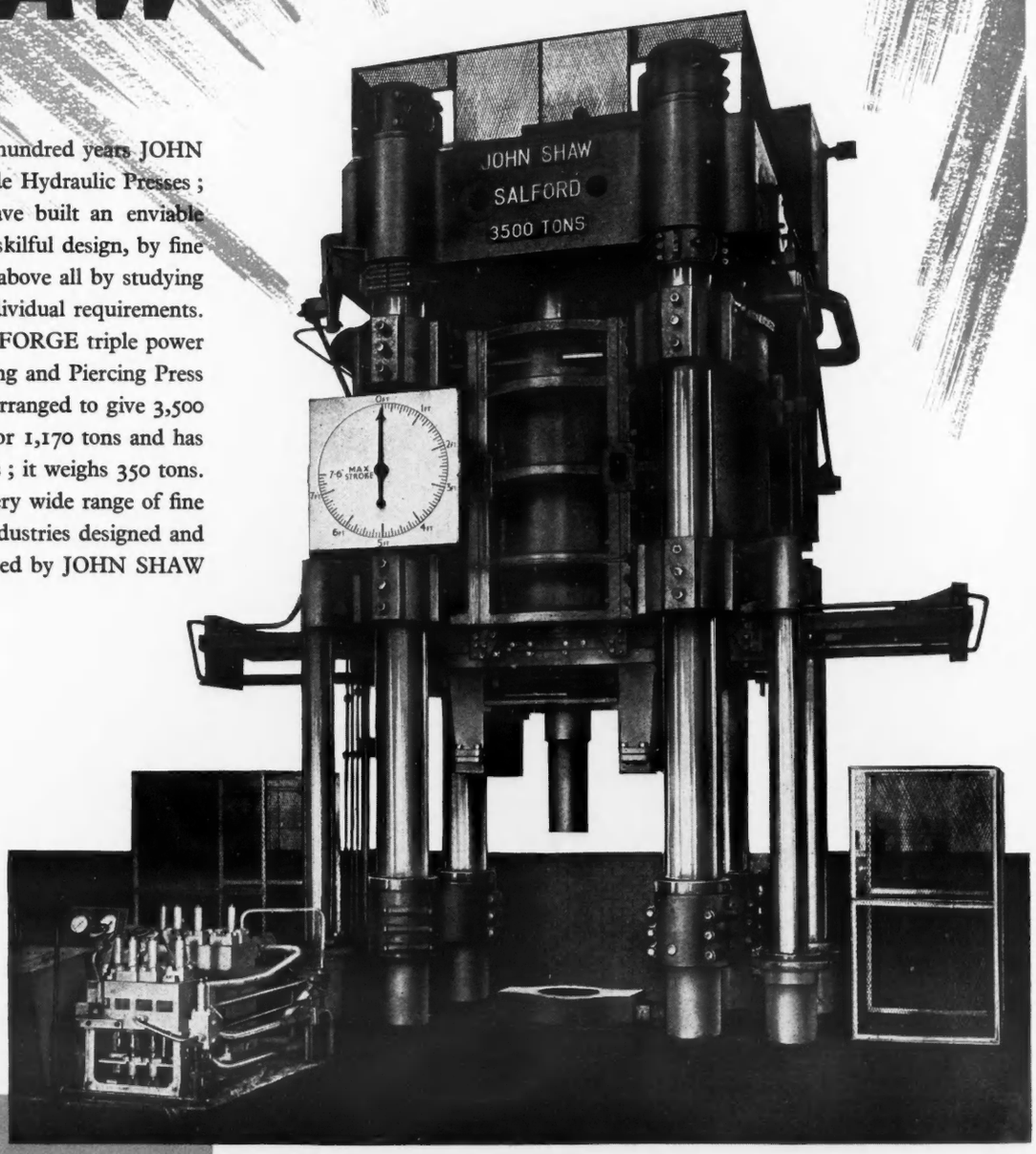
For over a hundred years JOHN SHAW have made Hydraulic Presses ; they have built an enviable reputation by skilful design, by fine workmanship and above all by studying each customer's individual requirements. The SHAWFORGE triple power downstroke Forging and Piercing Press illustrated is arranged to give 3,500 tons, 2,330 tons or 1,170 tons and has three main rams ; it weighs 350 tons. It is but one of a very wide range of fine presses for many industries designed and manufactured by JOHN SHAW



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Among the presses built by JOHN SHAW are :
PIERCING, FLANGING and BENDING PRESSES ; SHEET METAL WORKING PRESSES ; BALING PRESSES ; PLYWOOD and VENEER PRESSES ; LAMINATED PLASTIC SHEETING PRESSES ; RUBBER VULCANIZING PRESSES ; DE-WATERING PRESSES FOR WET BOARDS ; SCRAP METAL BALING PRESSES ; REFRACTORY BRICK MAKING PRESSES ; PRESSES FOR POWDER METALLURGY Etc. Etc.
All these and many others are described and illustrated in Catalogue No. 59 which we have recently produced.

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DRAKELOW 'C' POWER STATION

DRAKELOW 'C' will be the first Central Electricity Generating Board power station to be equipped with boiler plant operating at supercritical pressure.

The boiler to be supplied by

BABCOCK & WILCOX LTD

will comprise a 'once-through' unit, pulverized-fuel fired, with an evaporation of

2,500,000 lb./hr.,

with steam conditions of

3,650 lb./sq. in. (s.o.p.)

1,110°F

AND REHEAT TO 1,055°F, 713 lb./sq. in. to steam a

375 MW GENERATOR

This Company, which is able to draw upon a considerable experience of supercritical-pressure boiler plant in other Babcock installations, is proud to be in the forefront of this important advance, with its potentiality for valuable increases in power station overall thermal efficiencies.

BABCOCK & WILCOX LTD., BABCOCK HOUSE, 209 EUSTON ROAD, LONDON, N.W.

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Forming half rings of 2″ × 7″ material to a diameter of 5′ 0″ on medium power press. Typical of robust Henry Berry design.

METAL FORMING *Machines*

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For bending heavy plates progressively.

Control of diameters during forming process effected by fine adjustment of built-in dies.

Capable of bending plates close to the edge.

We also manufacture: *High Pressure Hydraulic Plant for Shipyards and Railway Workshops, Plate Bending Rolls, Punching and Shearing Machines, Continuous Finishing Presses for Silks and Rayons, Veneer and Plywood Presses, Cotton Baling Presses, Die Spotting Presses, Pumps, Accumulators, Valves and Intensifiers.*

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This is our sole concern, making steel, steel made to measure, to your particular requirements. Why not send for your armourer now?

THE STEEL COMPANY OF WALES LIMITED

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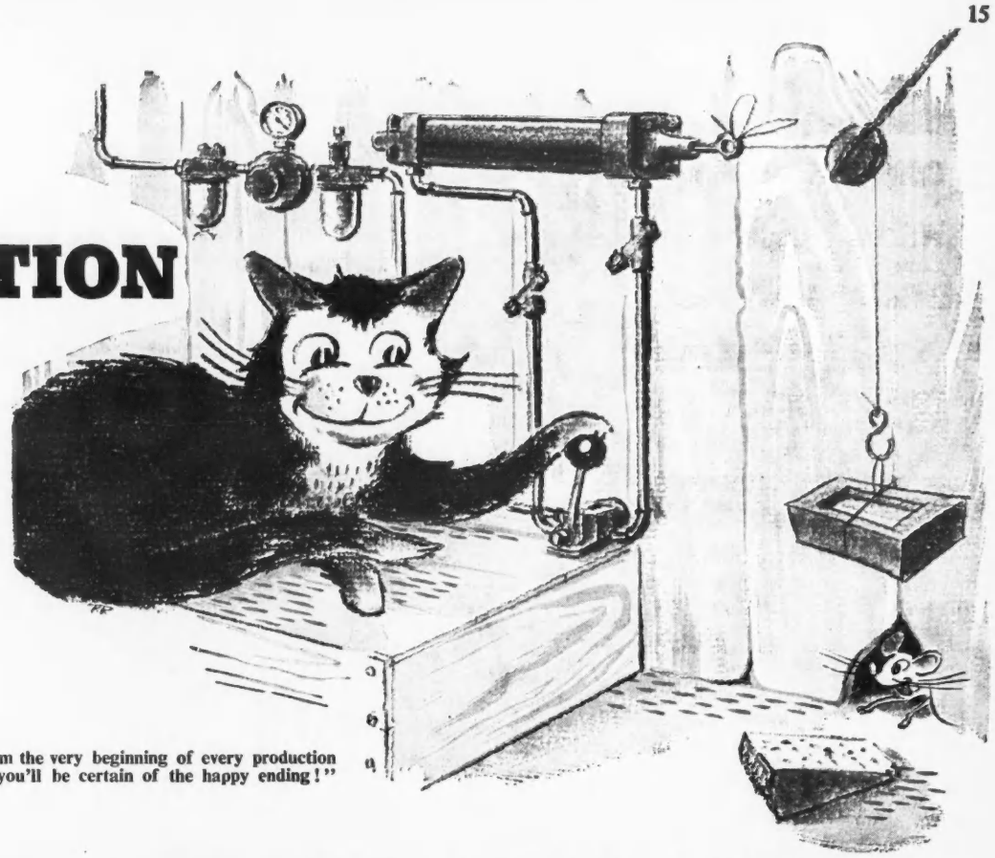
PNEUTOMATION



There's a 'situation vacant' in every firm for the tough, willing worker who never tires, never makes an error, will tackle anything—in short, 'Pneutomation.' 'Pneutomation'—Lang Pneumatic air-power systems—is the guiding hand behind a host of jobs, from jig-boring to bell-ringing, providing accurate, low-cost control of complex or simple operations. You can enjoy the benefits of 'Pneutomation' at less capital cost than you'd think—the system you need is more than likely available 'off-the-shelf' from the enormous range of standard 'Pneutomation' components

Squinch says :
"Plan with Lang Pneumatic from the very beginning of every production venture—right from the start, you'll be certain of the happy ending!"

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OWEN ROAD, WOLVERHAMPTON
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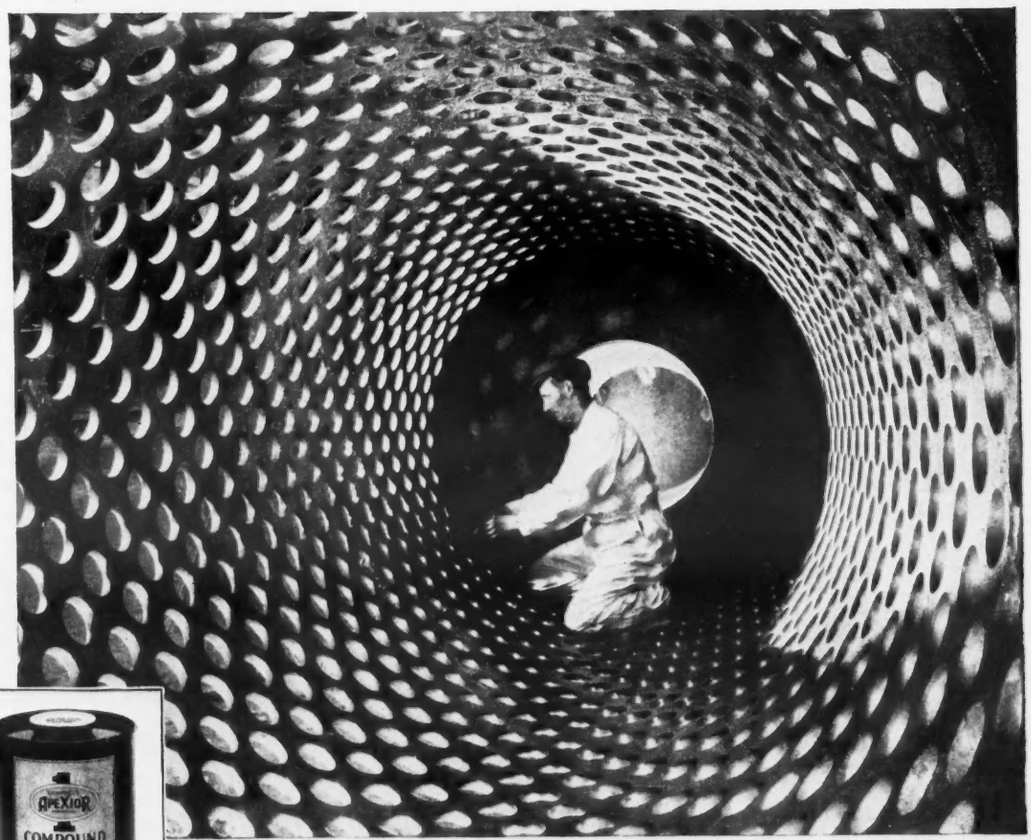
All round protection against corrosion



Wherever hot-wet metal surfaces are found —with temperatures above 170°F—'Apexior No. 1' prevents corrosion.

Easily applied by brush or spray this outstanding coating provides effective *low cost* protection for expensive boiler plant . . . means less costly maintenance.

'Apexior No. 1' minimises scale formation, ensures that any scale which does form will be easier to remove; heat transmission is improved and feed water will not be contaminated or discoloured. For full information about 'Apexior No. 1' write today for booklet "Preventing Boiler Corrosion".

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COMPLETE PLANT
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Waste Recovery
and
Effluent Treatment

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DESIGNERS AND SUPPLIERS OF ALL PROCESS PLANT

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INDUSTRIAL COUNTING INSTRUMENTS and MEASURING MACHINES

Let us solve your counting and measuring problems

Write or phone for our Catalogue or a visit from a technical representative to "INSTRUMENT DIVISION"
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"Goin' like a bird with them new L & C Piston Rings, ain't she, Chief?"

"Eh?"

"Engines . . . . like a bird . . . . lovely!"

"Och, ye mean that wee lassie in Liverpool?"

"No, I'm not talkin' about 'er!"

"Which one are ye talkin' aboot then? Ye'd do far better to keep your mind on the engines. Don't ye think they're goin' like a birrrd since we fitted those L & C piston rings?"

LOCKWOOD & CARLISLE LTD

Manufacturers of the well known "Patent Double Action Piston Rings" for steam engines

MAKERS OF THE WORLD'S FINEST DIESEL PISTON RINGS

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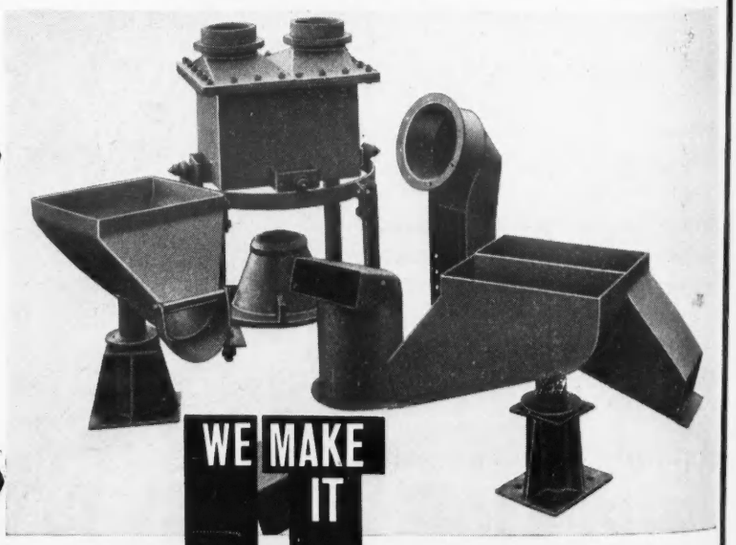
YOU DESIGN IT

YOU NAME IT

WE DESIGN IT

WE MAKE IT



IT being a quality fabrication in mild or stainless steel, or light alloys

SPENCER & SONS
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We shall be pleased to have your enquiries. GREAT BOWDEN ROAD MARKET HARBOROUGH TEL 2651

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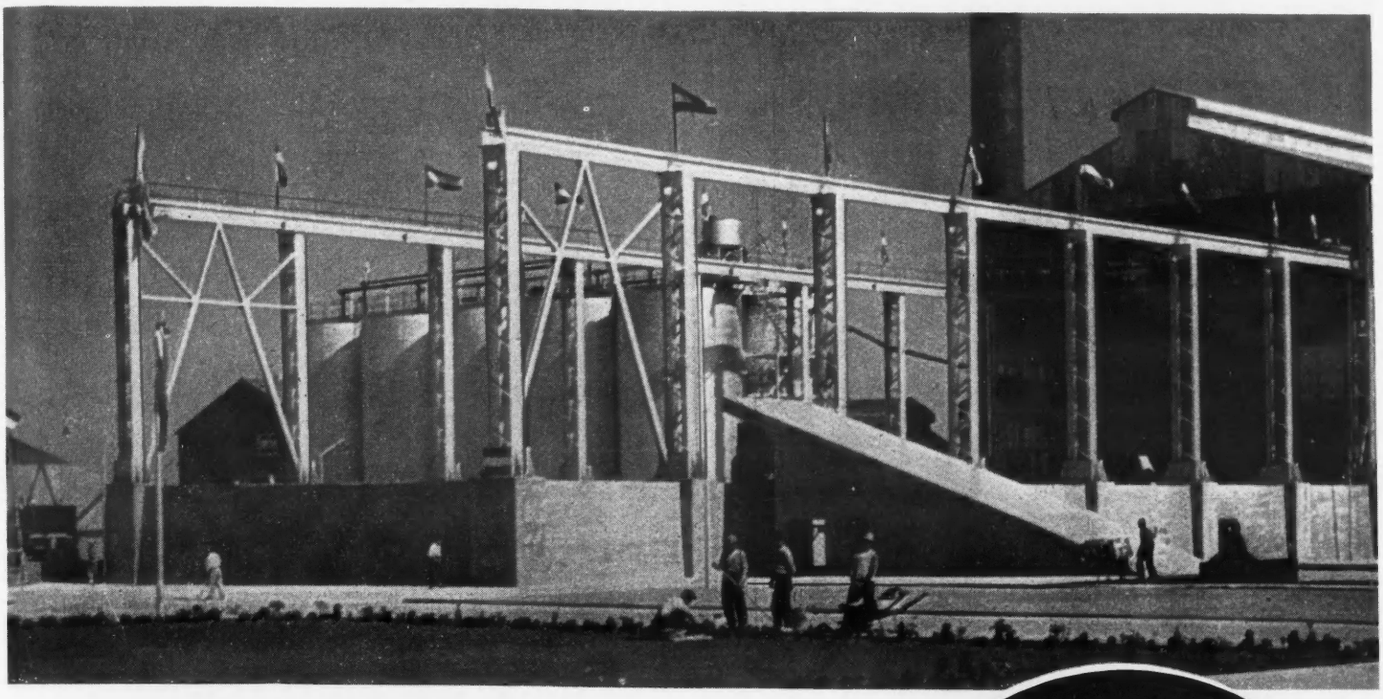
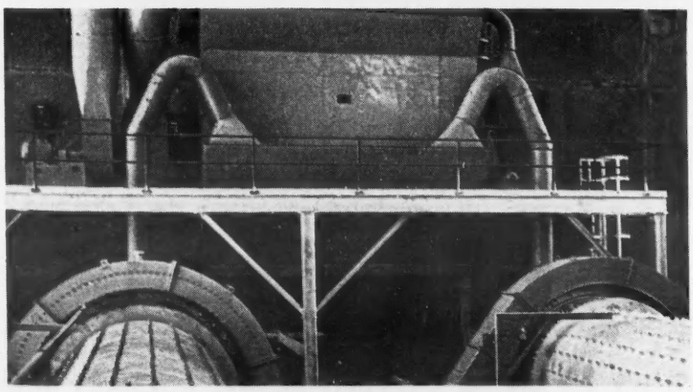


New Cement Works in Iran

MECHANICAL PLANT manufactured and erected by EDGAR ALLEN & CO. LIMITED



The area around Doroud in Iran is rich in raw materials, and those for the manufacture of cement lie conveniently close at hand. Here Edgar Allen & Co. Limited have supplied the country's most modern cement plant which has a capacity of 600 tons of Portland Cement per day. By a combination of engineering skill and metallurgical knowledge, we design and manufacture all the machinery for the efficient and economical production of cement from the processing and crushing of raw materials to the despatch of the finished product.

Messrs. Henry Pooley (Consulting Engineers) of London were the Consultants.

Have you had our publication: 'Choosing a Cement Plant'?

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Please post "Choosing a Cement Plant" to

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IMPERIAL STEEL WORKS · SHEFFIELD 9

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- SUITABLE FOR HANDLING MOST INDUSTRIAL GASES
- NO CONTAMINATION FROM INTERNAL LUBRICATION
- CONSTANT HIGH VOLUMETRIC EFFICIENCY
- LOW OPERATING COSTS
- LONG LIFE

PRICE REDUCTIONS OF UP TO 20%

PLUS IMMEDIATE DELIVERIES

As a result of recently introduced "production line" manufacturing methods, we are able to offer the twin advantages of greatly reduced prices and immediate deliveries of Holmes-Connersville Positive Air Blowers within the following size ranges.

Capacities up to 450 c.f.m. at pressures up to 8 lb.p.s.i.
Capacities up to 700 c.f.m. at pressures up to 5 lb.p.s.i.

Larger sizes of Holmes-Connersville Positive Air Blowers can be delivered to clients' requirements.

Holmes-Connersville Positive Air Blowers have been designed to give continuous trouble free service and are consequently of extremely sturdy construction. This, combined with minimum maintenance and low running costs, makes them eminently suitable for a wide range of applications where air is required at pressures up to 10 lbs. per square inch. They are also suitable for low and medium vacuum conditions.

W. C. **HOLMES** & CO. LTD.

Gas Handling Division, Turnbridge, Huddersfield

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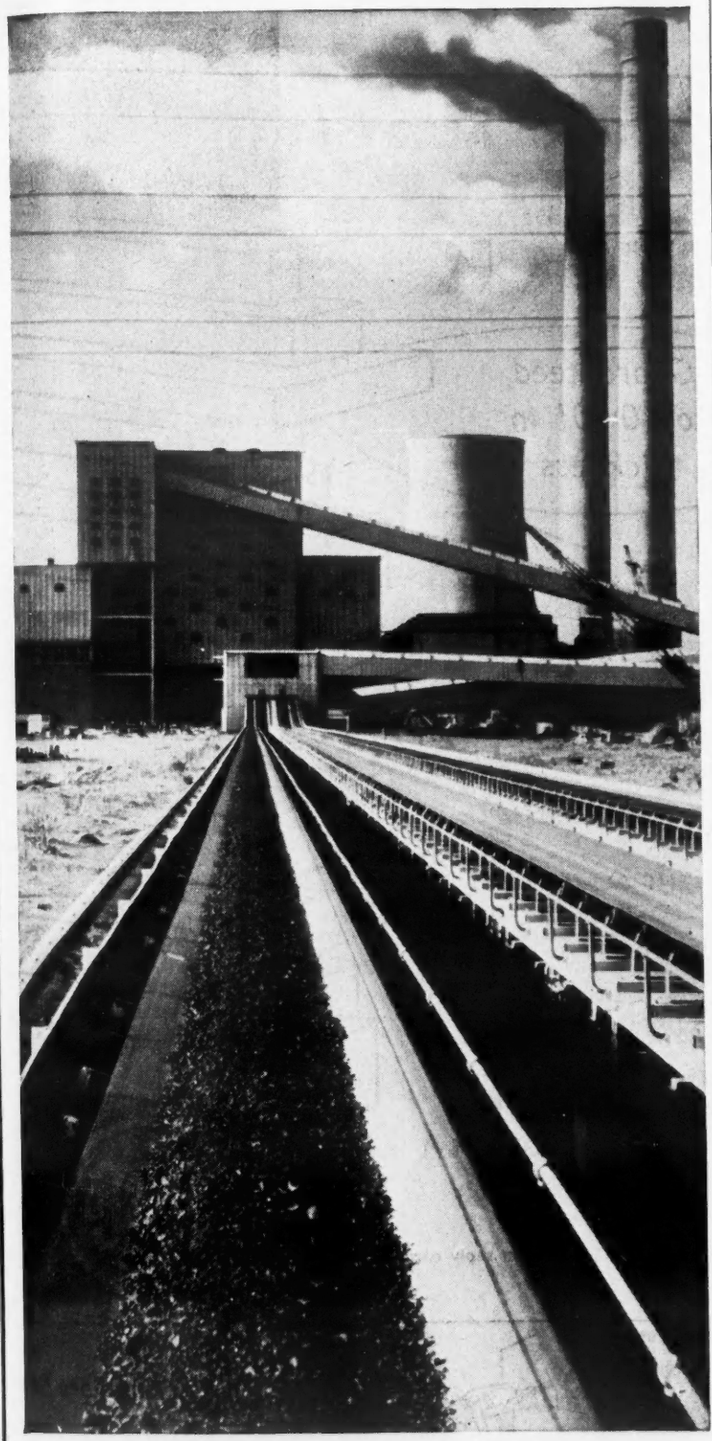

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—the patented mechanical method of hacking old and damaged concrete to a precise depth, and providing an evenly keyed sub-surface to receive new topping.

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TEL : 2876 'GRAMS : 'FRAMES' S'LAND

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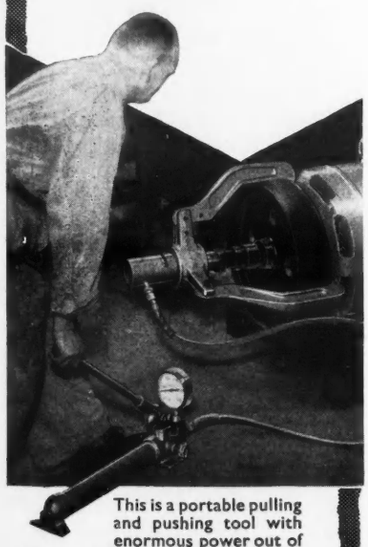
Always a busy tool in any works...



This is a portable pulling and pushing tool with enormous power out of all proportion to its compact size. It can be put to work on a wide variety of ordinary maintenance jobs. It will be invaluable for awkward jobs, working in a confined space or where extra power is required to shift stubborn gear wheels, pulleys or machinery. Always it will save labour and valuable man-hours. Models up to 100 tons capacity.

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Range of 3 to 100 tons capacity

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Removal of pulleys, gears, bushes, etc., can be undertaken quickly and economically.

PUSHING
For assembly or wherever power is required for moving machinery, the "LOADSTAR" is invaluable.

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Demonstrates the versatility of the "LOADSTAR" which can work in very restricted spaces.

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For all these jobs it is only a matter of minutes to secure the required "set-up."

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Attachments for bending tubing to B.S.1387 up to 2" diameter.

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In addition to the Heavy Duty Kits dealt with above there are also Small Kits from £9 10s. 6d.

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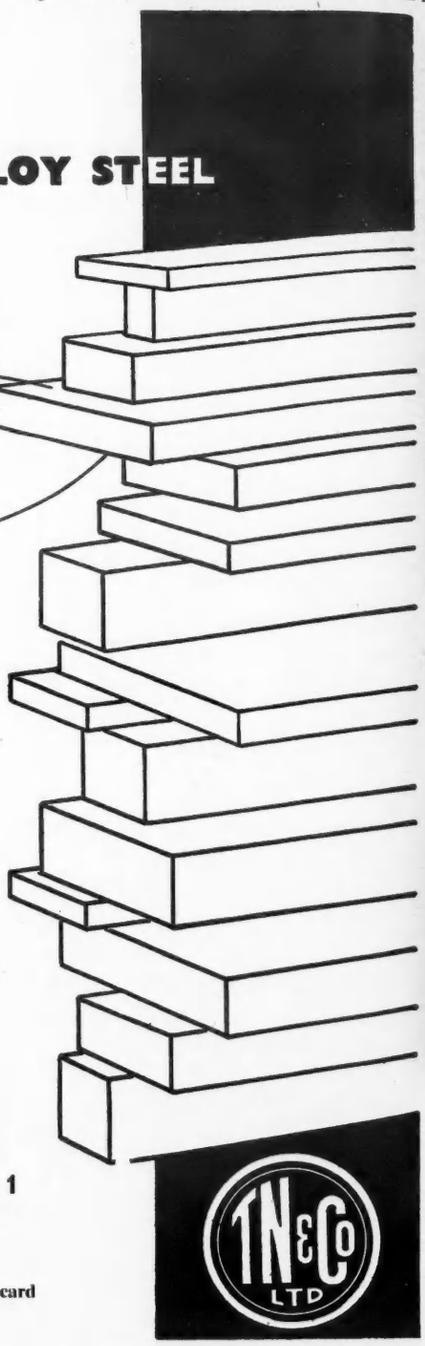
CARBON CHROME ALLOY STEEL

GROUND FLAT STOCK

Guaranteed to ± 0·001 in thickness



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30,000 LENGTHS ALWAYS IN STOCK

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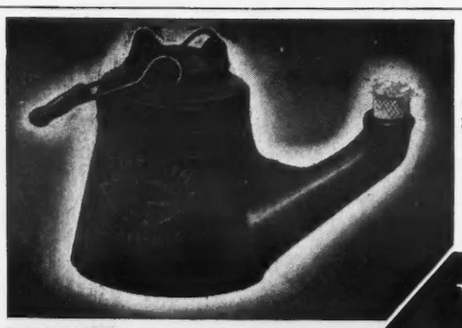

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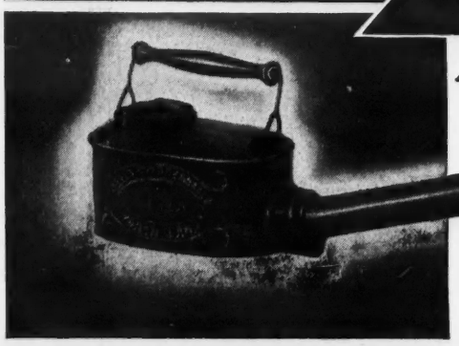
No. 18 KETTLE TORCH LAMP
CAPACITY 3 PINTS PARAFFIN



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THE GUIDING LIGHT ON A GLOOMY NIGHT.

No. 18a TRENCH LAMP. 5 PINTS CAPACITY

Also makers of Wells Waste Oil Filters, Oil Storage Cabinets, Barrel Pours, Lathe Drip Cans, Portable Industrial Oil Heaters, Lime Spraying Machines and Spray Guns.

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There is virtually no speed drop under load and faster work is the result, with a better and constant finish.

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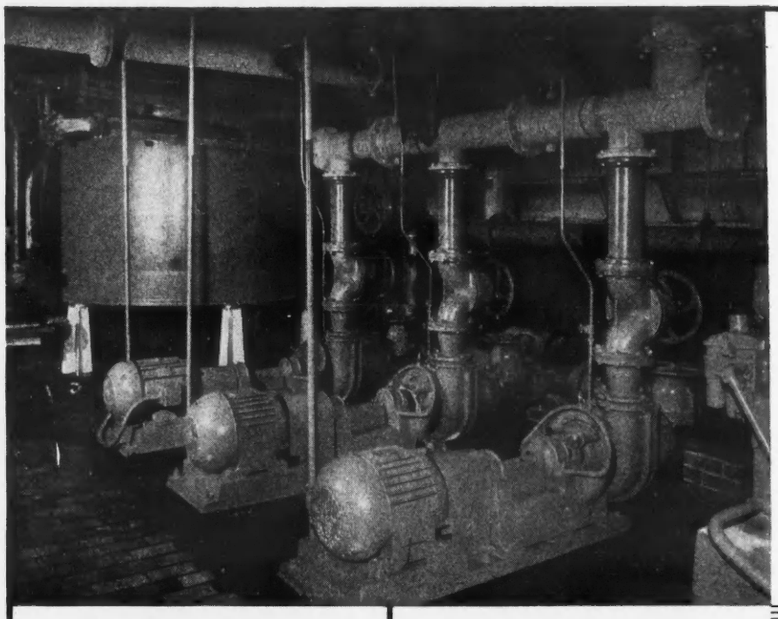

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Zinc Leach for batch and continuous galvanising processes

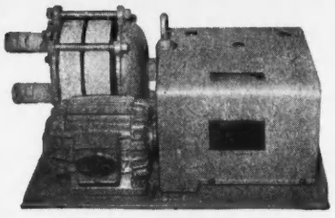
Sulphuric Acid and contaminated wash waters on pickling tanks and continuous pickling plants

Chromic Acid and Nickel Solutions for electrolytic plating plants including pumping to filters, etc

Waste pickle liquor and acidic effluents for neutralisation prior to disposal

Pumping of demineralised water

(Top left) Large battery centrifugal acid pumps
(Bottom left) Close-up view of diaphragm pump similar to the hand operated unit but arranged for motor drive
(Bottom centre) Hand operated portable diaphragm pump for emptying carboys or tanks and for general duties.
(Bottom right) Portable rotary displacement pump pumping plating solutions in the motor car trade



MITCHELL PUMPS give complete freedom from metal contamination of the liquids

SPECIALISTS IN ACID PUMPS

THE MITCHELL ORGANISATION

Consult the Acid Pump Division of

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TEL. BLA 7224/7 AND 7824/7

LONDON OFFICE: PORTLAND HOUSE, 73 BASINGHALL ST., LONDON, E.C.2
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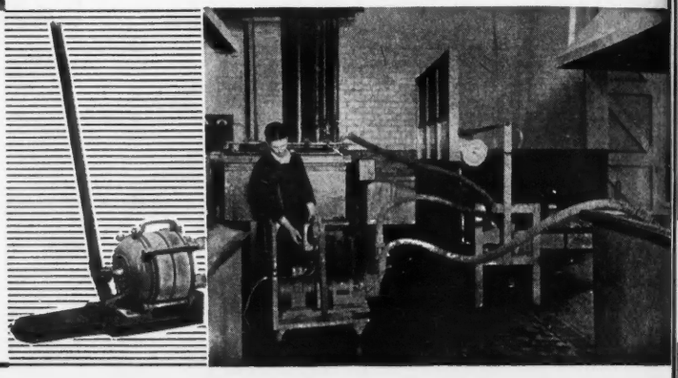

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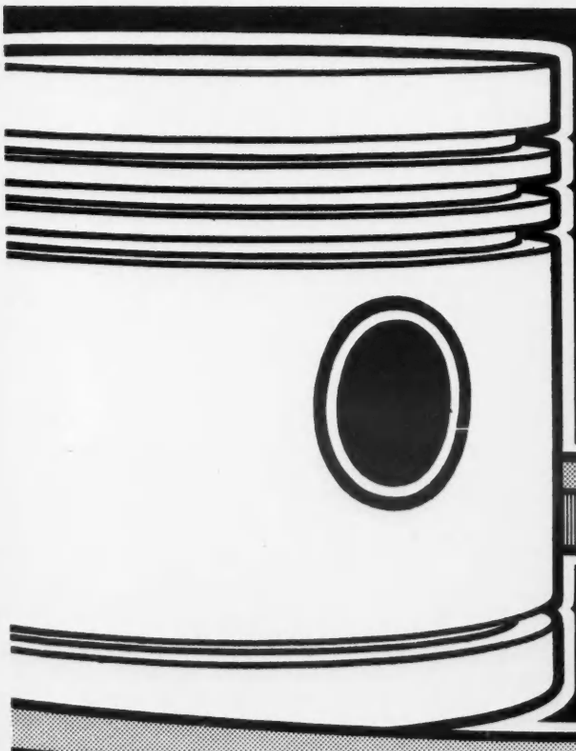

Run rings around them . . .

You can choose from Standard's Outstanding Range of PISTON RINGS AND ASSEMBLIES for any type of engine . . . Steam, Petrol or Diesel . . . also for compressor and hydraulic use.

. . . but make sure they are Standard's

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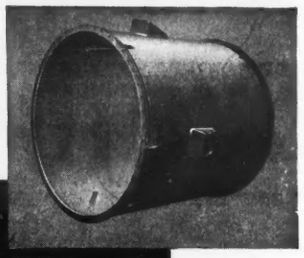
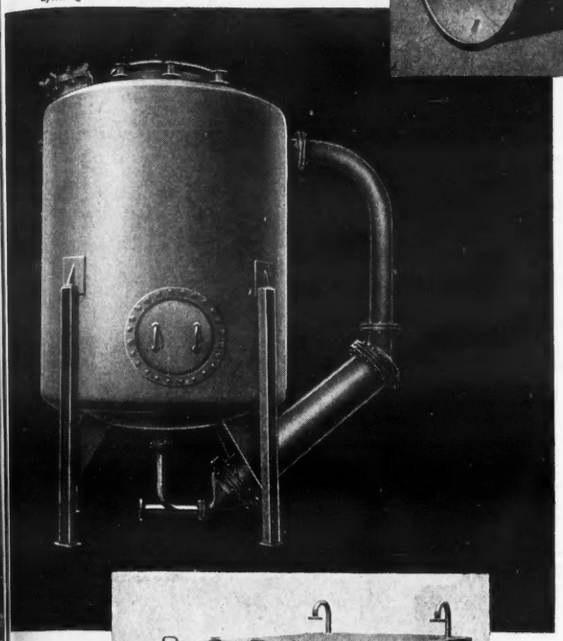


Stainless steel vessel with mild steel jacket

1,000 gall. kettle in ½" copper. Lynx Quasi-arc welded.



12,000 gallon water separator

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Metallic Arc Welding

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Stress-Relieving and Testing Facilities

WELDED FABRICATIONS

Ordinary or Extraordinary

CLARKS CAN COPE!

Clark's modern methods, efficient equipment, unique facilities and practical approach all operate to your advantage....

Clarks offer you a unique combination of the most advanced equipment and methods with a century-old reputation for high craftsman standards on every type of fabrication work.

Stainless steel, mild steel, aluminium, copper, or aluminium-bronze ... Clarks of Hull will not only give you the practical solution to your problem—they'll deliver a first-class job on time !

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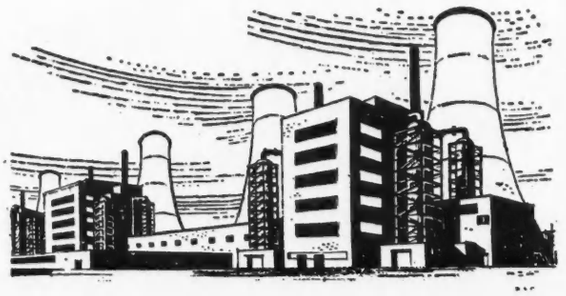
THERMAL INSULATION BY

Newalls

Throughout the years Newalls have built an enviable reputation in the insulation of conventional power stations. This specialised experience is now being drawn upon on an ever growing scale in solving the complex problems of Nuclear Power Development. Recent contracts in this field reflecting Newalls supremacy are given below.



HINKLEY C.E.G.B. NUCLEAR POWER STATION

At Hinkley Point, Newalls have been entrusted with the insulation of the reactors, steam raising units, gas ducting, integral piping, etc., under contract to Babcock and Wilcox Ltd.

CHAPELCROSS U.K.A.E.A. NUCLEAR POWER STATION

Under contract to Babcock and Wilcox Ltd., Newalls are carrying out the insulation of the 16 steam raising units and integral piping. The insulation of turbines, blowers, associated auxiliary equipment and piping is being carried out under contract to C. A. Parsons and Co. Ltd.

BRADWELL C.E.G.B. NUCLEAR POWER STATION

At Bradwell-on-Sea a further large contract for the thermal insulation of turbines, associated auxiliary equipment and piping (main and auxiliary turbine plants) has also been placed by C. A. Parsons and Co. Ltd. with Newalls.

NEWALLS INSULATION COMPANY LIMITED

Head Office: WASHINGTON, Co. DURHAM

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Offices and Depots at: LONDON · GLASGOW · MANCHESTER · NEWCASTLE UPON TYNE · BIRMINGHAM · BELFAST · DUBLIN · BRISTOL & CARDIFF

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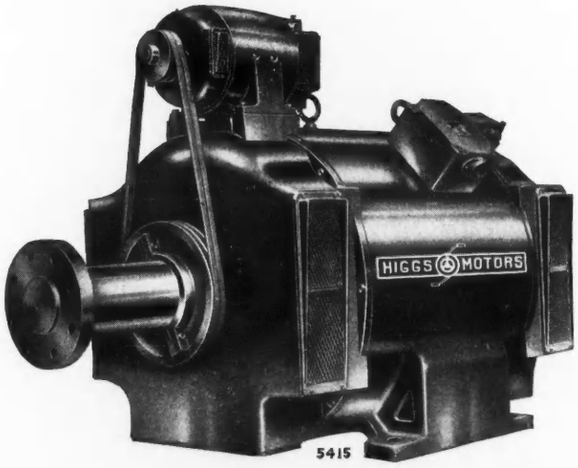
HIGGS MOTORS LTD.

MANAGING DIRECTOR DAVID C.Y. HIGGS, A.M.I.E.E.

BIRMINGHAM 6 ENGLAND



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BELFAST BRISTOL CARDIFF DUBLIN DUNDEE GLASGOW HULL LEEDS LIVERPOOL LONDON MANCHESTER NEWCASTLE PETERBOROU
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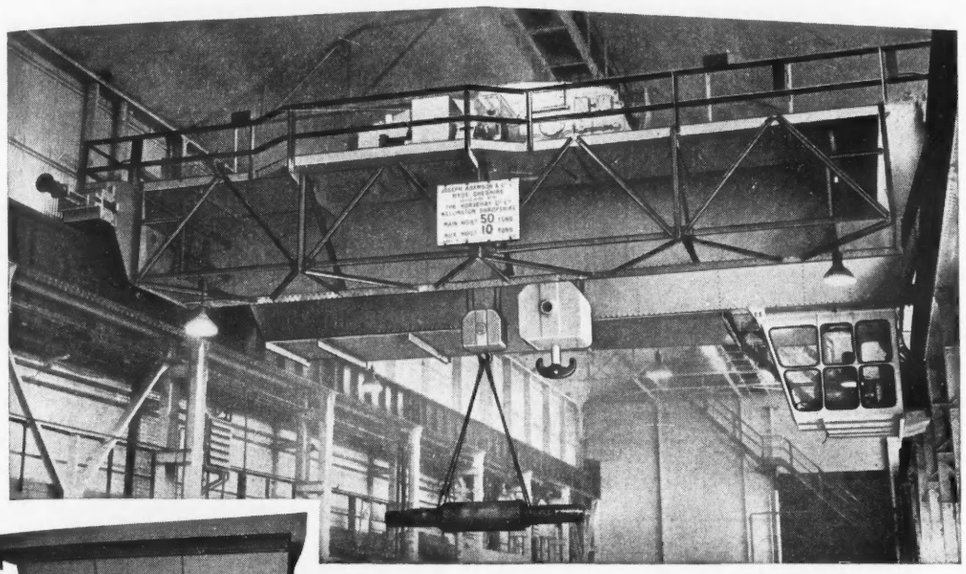
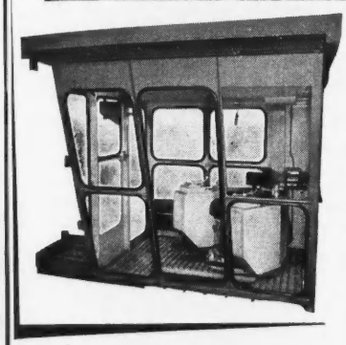
JOSEPH ADAMSON
ELECTRIC OVERHEAD TRAVELLING CRANES





★ *a view of the cab showing the seat control unit.*

The Adamson 50/10 ton crane is the third of a series of new design supplied to Richard Thomas & Baldwins Limited, Ebbw Vale Section. Features of the crane include monolithic construction of the crab and the elimination of castings by mild steel fabrication of the hoist barrel and bottom block. The cab is of particular interest as it incorporates the most modern type of seat unit ensuring maximum vision and ease of control. Joseph Adamson electric overhead travelling cranes can be supplied to all specifications including cranes suited to the most exacting 24 hours-a-day process work.

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THE ADAMSON GROUP

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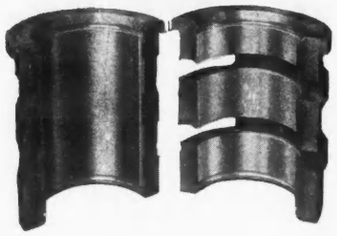

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SIRRON
Diesel Engines

Main Propelling Diesel Engines in powers up to
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THE NEWBURY DIESEL CO. LTD.
NEWBURY, BERKS

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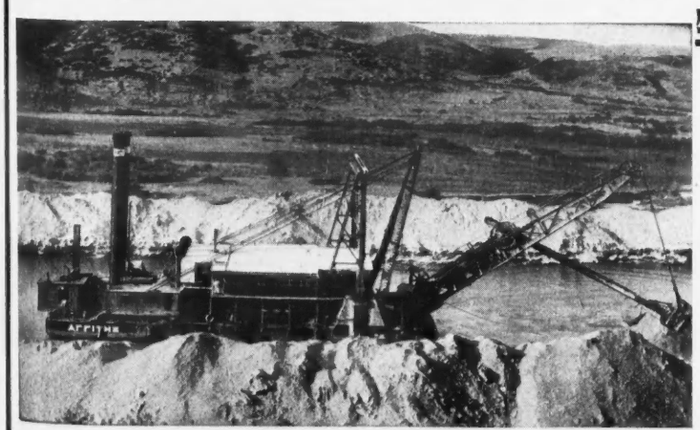

6-yard oil-fired Steam Dipper Dredger, built for the Greek Government. Output 255 cubic yards of cobbles and boulders per hour dumped to a radius of 90 feet and a clear height of 30 feet.

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to the Largest Dimensions and Capabilities.

PATENT CUTTER HOPPER DREDGERS, PATENT DIPPER DREDGERS, BUCKET DREDGERS, GOLD & TIN RECOVERY DREDGERS, FLOATING CRANES

Hopper Barges
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New Buckets,
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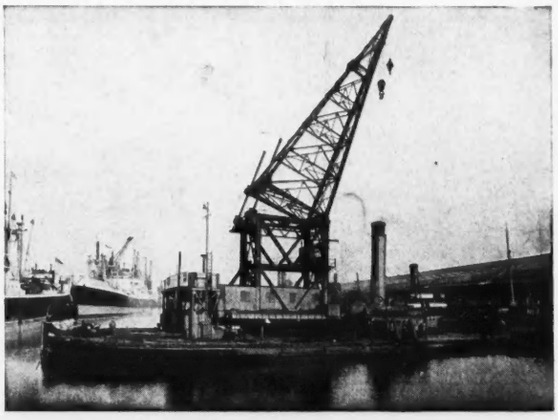

Crane Steamer M.O.W.T.8 built for Ministry of War Transport. Dimensions: 173 feet by 57 feet by 12 feet 6 inches. Load: 60 tons at 80 feet radius.

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IMMEDIATE DELIVERY
is offered of all the following foot-mounted induction motors. The ratings listed are for 400/440 volt, 3-phase, 50-cycle supplies.

SQUIRREL CAGE (BS 2613)			
Screen-protected		**Totally enclosed fan-cooled**	
h.p.	*speed r.p.m.*	*h.p.*	*speed r.p.m.*
30	970	25	730
30	725	40	975
50	1460	40	730
50	725	50	1475
*55	720	50	730
70	720	65	1475
*75	970	65	975
100	1455	75	1475
100	725	85	975
*125	1465	100	1480

SLIPRING (BS 2613)			
Screen-protected		**Totally enclosed fan-cooled (one-hour rated)**	
h.p.	*speed r.p.m.*	*h.p.*	*speed r.p.m.*
30	965	30	965
50	1450		

**drip-proof enclosure*

For further details of these and other AEI stock motor ranges, please contact your local AEI district office or Industrial Machines Dept., Mosley Road Works, Trafford Park, Manchester 17. Telephone No. Trafford Park 2431. Extension 1212.

AEI

Associated Electrical Industries Limited
Motor & Control Gear Division
RUGBY & MANCHESTER, ENGLAND

COMBINING THE MOTOR & CONTROL GEAR INTERESTS OF BTH AND MV

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"SECURITY"—equipped washroom at Parkgate Iron and Steel Co. Ltd.

Do they provide, without wastage, an adequate supply of water, at a uniform, optimum temperature, and with complete dependability?

In other words, are they equipped with

'SECURITY' THERMOSTATIC MIXING VALVES

featuring multiple, bi-metal element coils which ensure smooth positive action and high efficiency.

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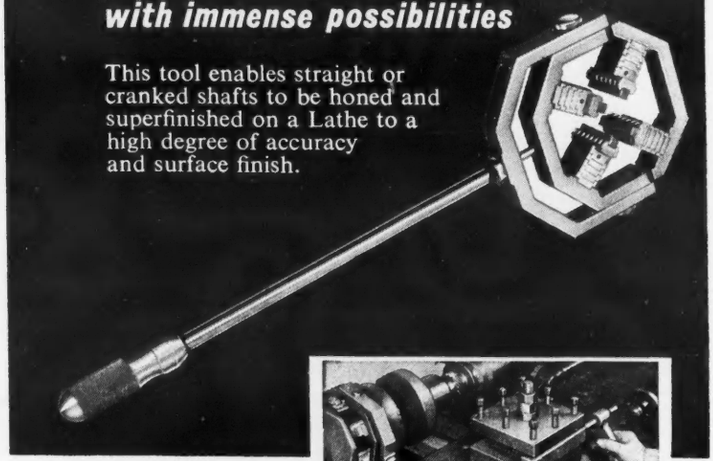
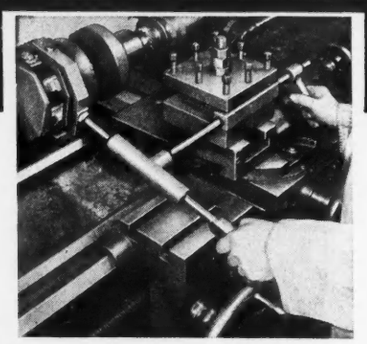
with immense possibilities

This tool enables straight or cranked shafts to be honed and superfinished on a Lathe to a high degree of accuracy and surface finish.





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A — 2"— 4" dia.
B — 4"— 6" dia.
C — 6"— 9" dia.
D — 9"—12" dia.

* **Low capital cost**
* **Fingertip control of Stone Pressure During Honing**

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NICOL & ANDREW (LONDON) LIMITED, 188 Uxbridge Road, Hanwell, London, W.7. Tel. Ealing 1088

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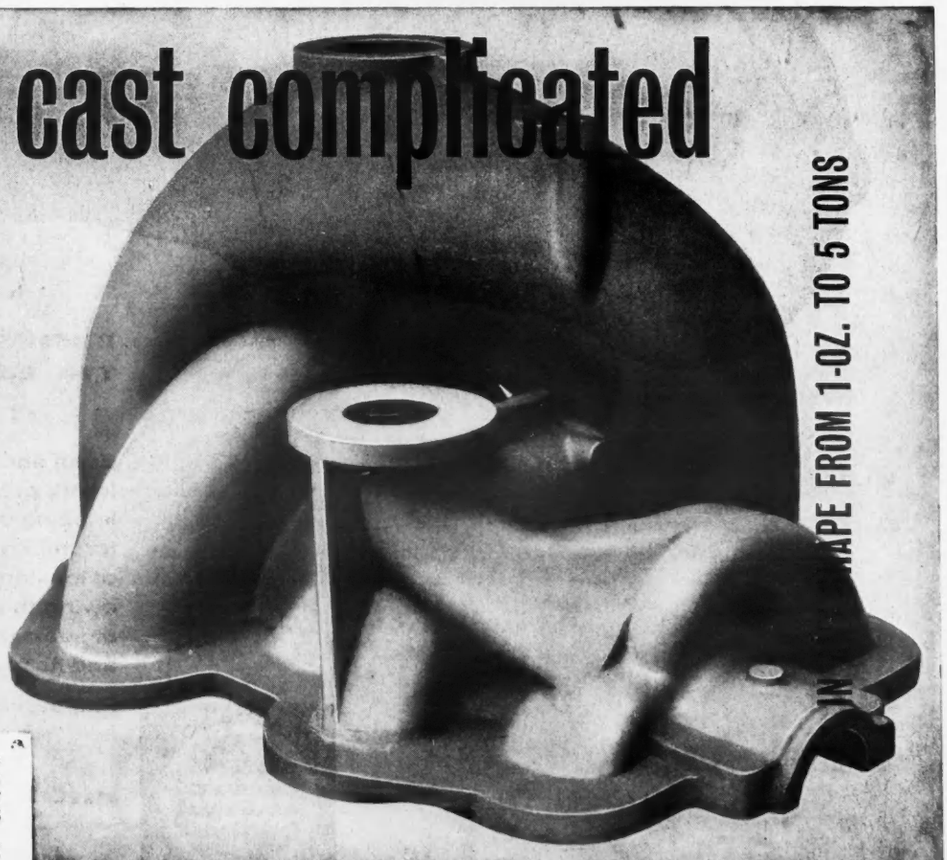
Large illustration shows a Shipham casting for a Centrifugal Pump Cover —overall length 4' 0"; weight 1330 lbs. Alongside — Centrifugal Pump Body — overall length 4'0"; weight 2425 lbs.

cast complicated



...APE FROM 1-OZ. TO 5 TONS

SHIPHAM & COMPANY LTD., HAWTHORN AVENUE, HULL

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able to resist low Temperatures
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Air liquefying plants,
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For equipment
exposed to very low temperatures
we developed our new

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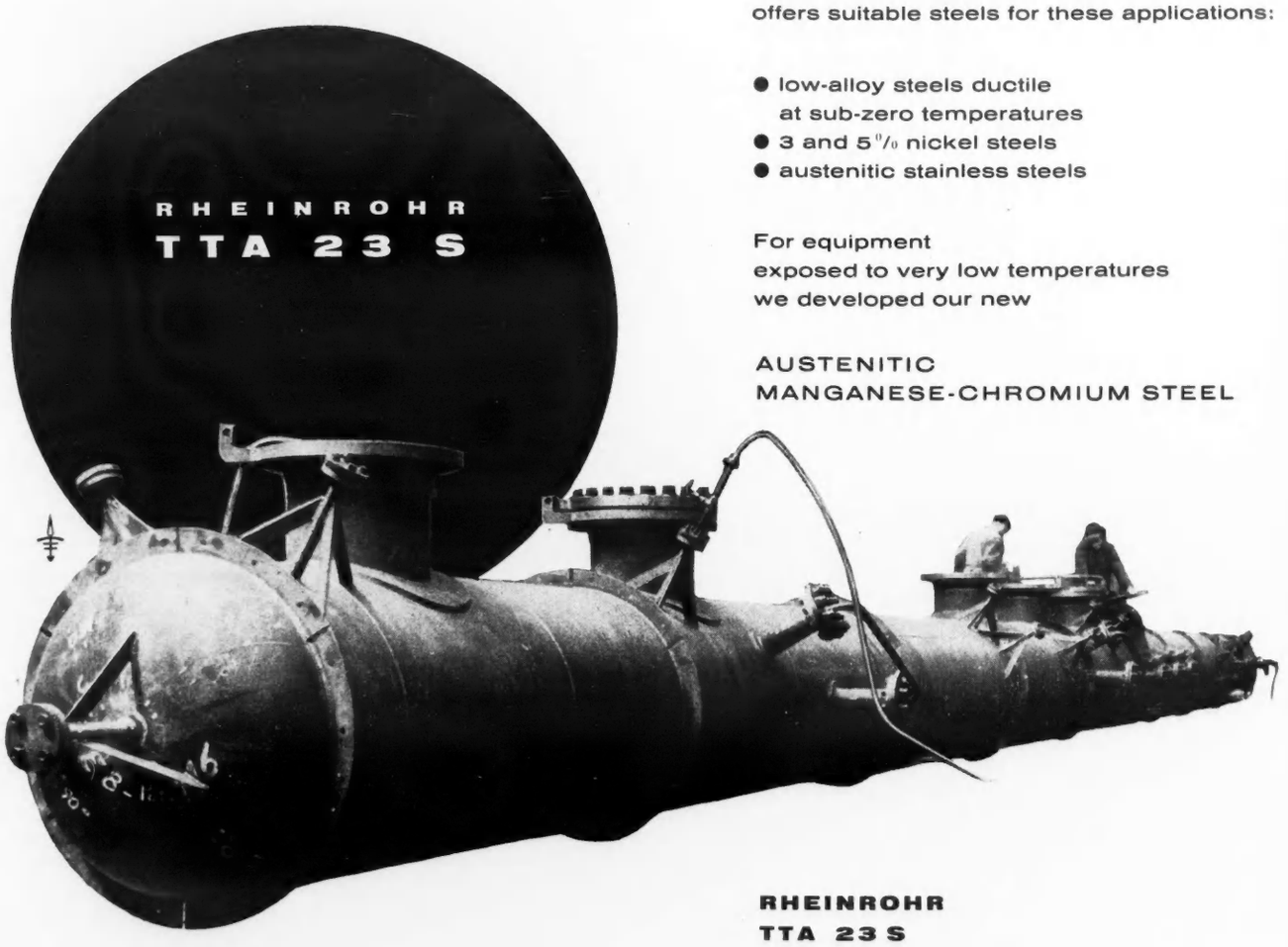
MANGANESE-CHROMIUM STEEL



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TTA 23 S

Even shortly after its inclusion
in our production program this steel
is being used to a fairly great extent
for the construction
of low-temperature plants
owing to its good ductility
at sub-sero temperatures
and its favourable price.

Please, write for our material sheets.

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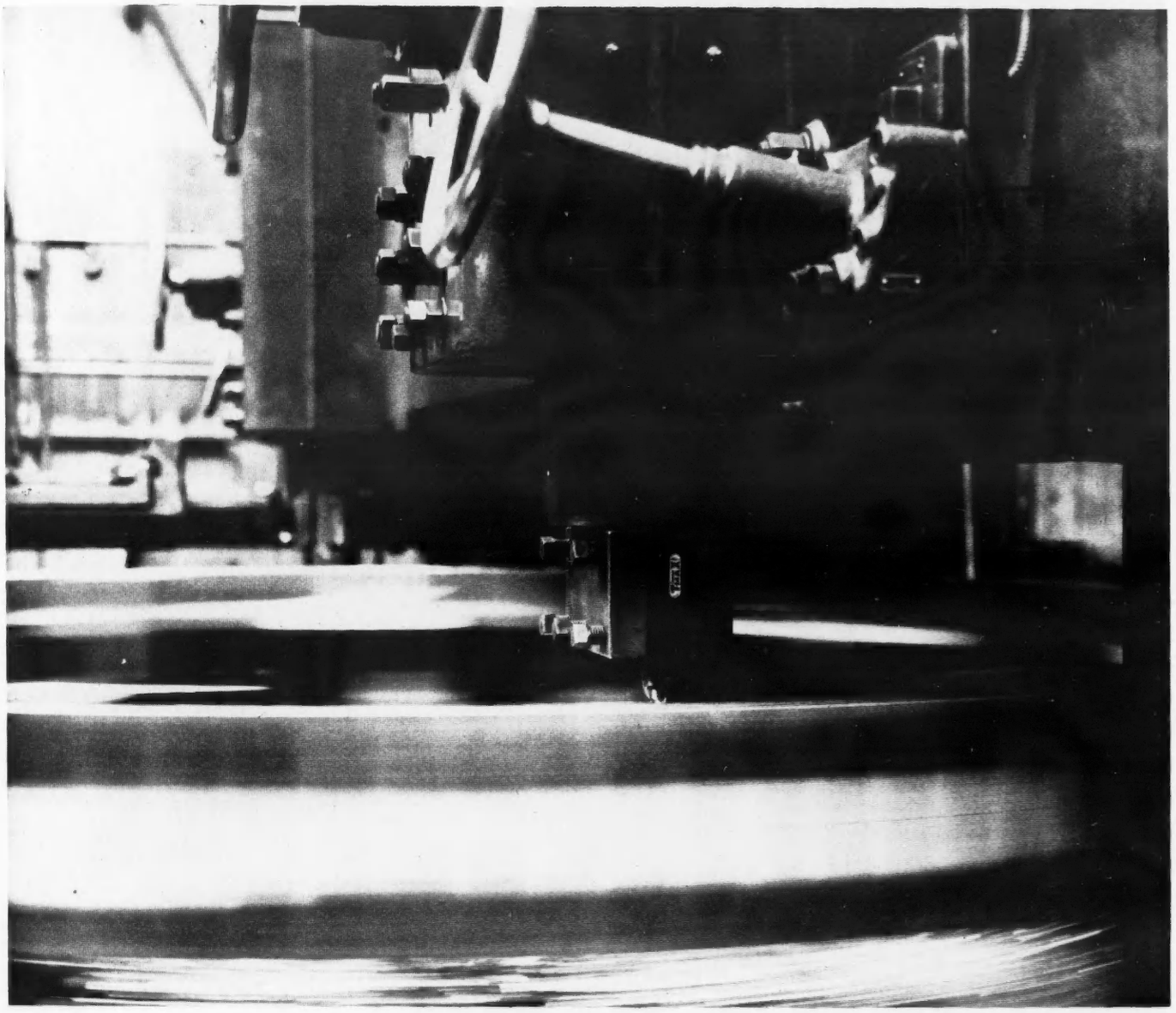

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the big stuff is nothing new for Crofts. They've been doing it for years. Really big stuff, too. Spur and helical gears up to 185 in. diameter, 37 in. face width, 5 in. CP—that's the way Crofts talk.

Here's a spur in Crofts fitting shop being turned into a powerful help to somebody, and it could be you. When it comes to big stuff (casting, machining and cutting), call Crofts—they've been doing it for years.

* *Customer's blanks can be cut and gears manufactured to special order, but remember Crofts STOCK RANGE includes Spur and Mitre Gear Drives up to 70 h.p. and Bevel Gears up to 44 h.p. We also produce Internal Gears, Racks and Pinions, Worms and Wheels, Spiral Bevels and Spiral Mitres. And Crofts can handle Steel Castings up to 8 tons ! Publication 159 tells the whole story—your copy's waiting.*

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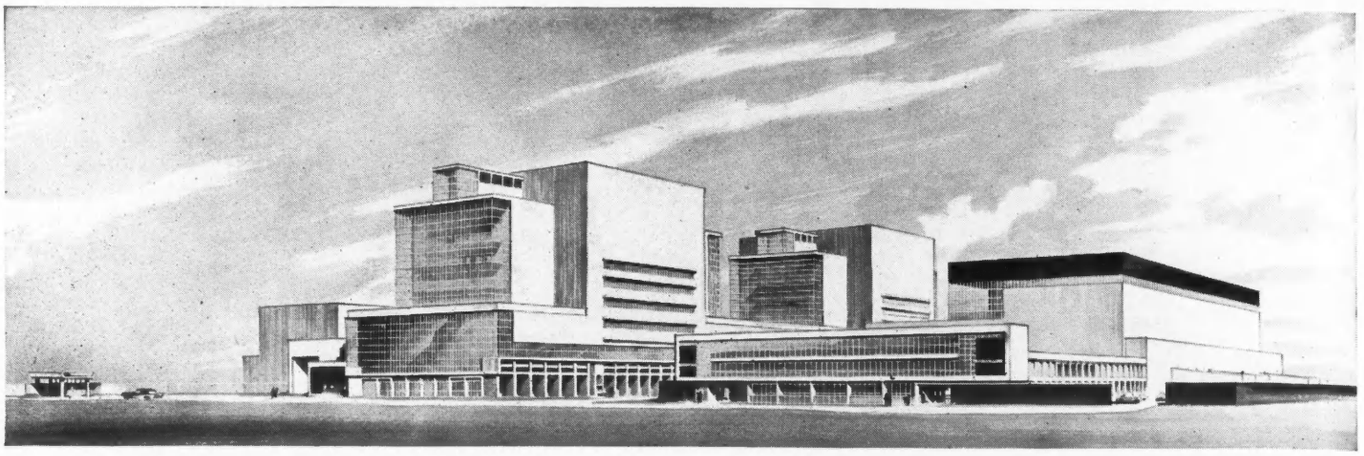

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—550 MW

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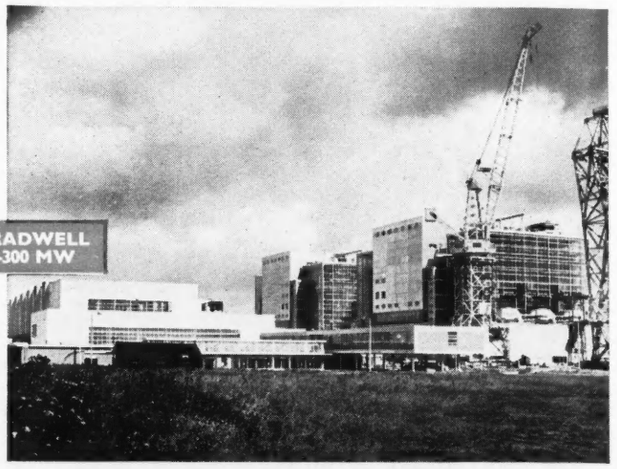
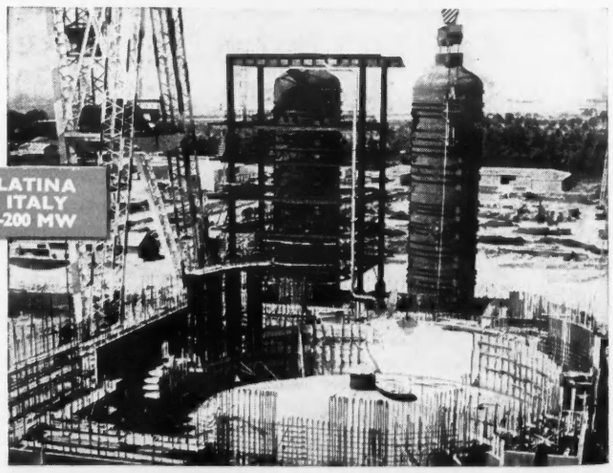


BRADWELL —300 MW

BERKELEY —275 MW



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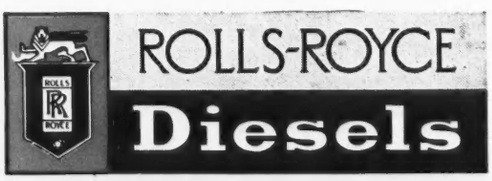
increased production means reduced costs

Due to rising output Rolls-Royce are now offering their engines at increasingly competitive prices.

These engines are now also available with higher specific outputs up to 450 b.h.p. for single engines, and still have rationalized spare parts throughout the range.

Spare parts coverage in over 100 countries.



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ROLLS-ROYCE—AERO ENGINES · MOTOR CARS · DIESEL AND PETROL ENGINES · ROCKET MOTORS · NUCLEAR PROPULSION

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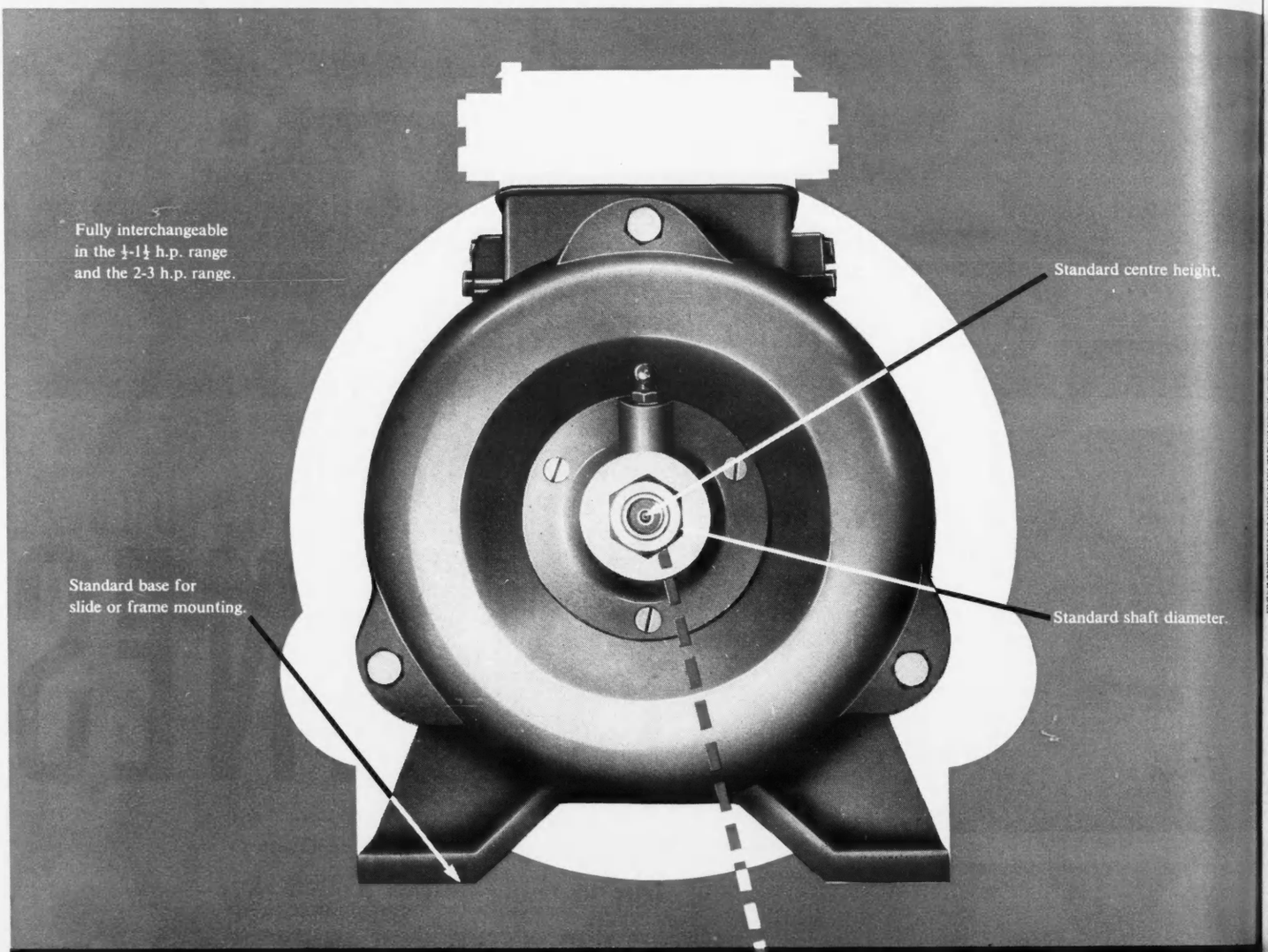
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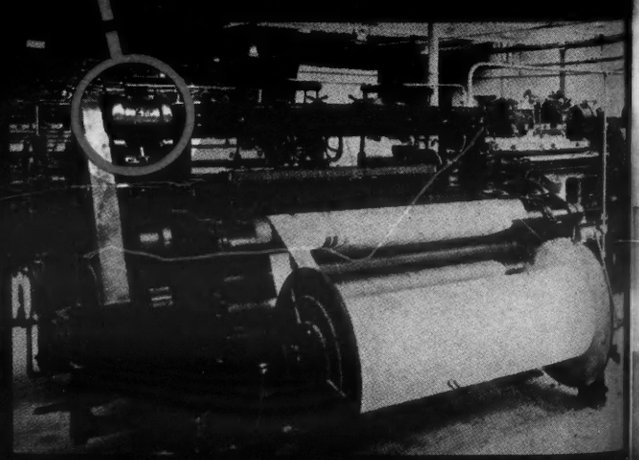
Standard centre height.
Standard base for slide or frame mounting.
Standard shaft diameter.

G.E.C. interchangeable loom motors

G.E.C. Loom motors seldom demand a moment's attention. Designed to develop a high starting torque, they ensure a correct first pick and beat up. To withstand the severe cyclical variations in speed and load imposed by the looms, the motors have to be as tough as indeed they are. Available from stock, G.E.C. motors are renowned for reliability, the quality which counts most. For full details write for Technical Description No. 347.



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THE GENERAL ELECTRIC CO. LTD. OF ENGLAND PLANT CO-ORDINATION DIVISION BIRMINGHAM 6

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Solution: **COLT Ventilation**

Place: **ARTHUR GUINNESS SON & CO**
Pomona Docks, Manchester Region.

Exhaust gases from fork lift trucks and lorries were once a major problem in this storage shed. Colt experts were called in to make a scientific analysis and on their recommendation a series of Colt S.R.C./3080 High Duty Extract Ventilators was installed. Fumes no longer bother anyone.

In providing a permanent solution to this ventilation problem Colt have added yet another chapter to their record of success—success which has brought repeat orders from many world-famous concerns.

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COLT VENTILATION LIMITED SURBITON SURREY TELEPHONE: ELMBRIDGE 0161

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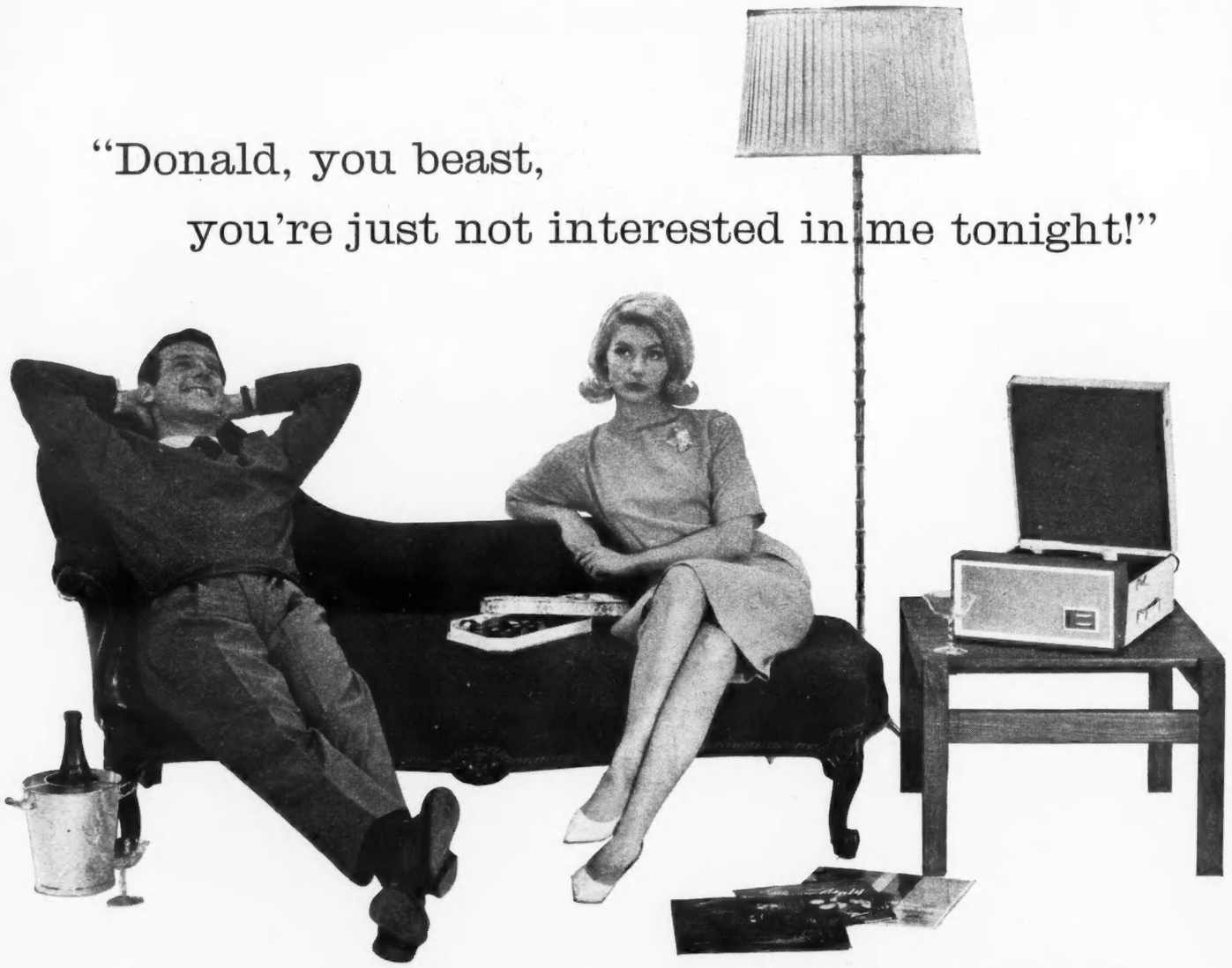
D

"Donald, you beast, you're just not interested in me tonight!"



"Sorry, Daphne, but something wonderful happened to-day. I discovered G.D. cone lock pipe-stoppers."

"Cone lock *whats*?"

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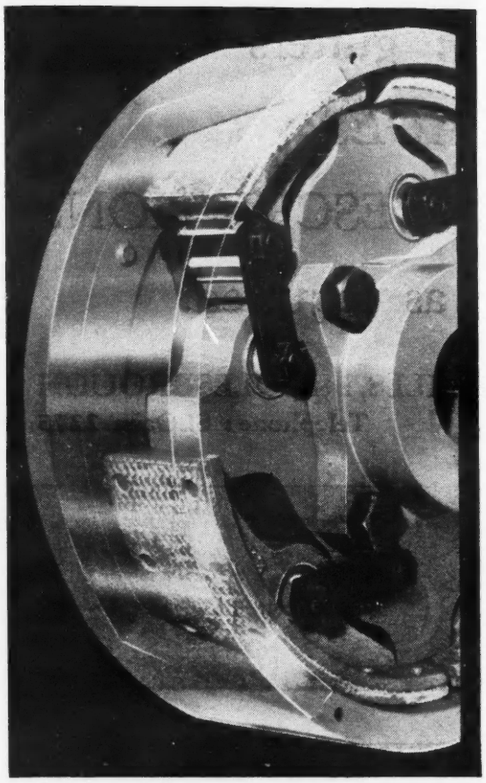

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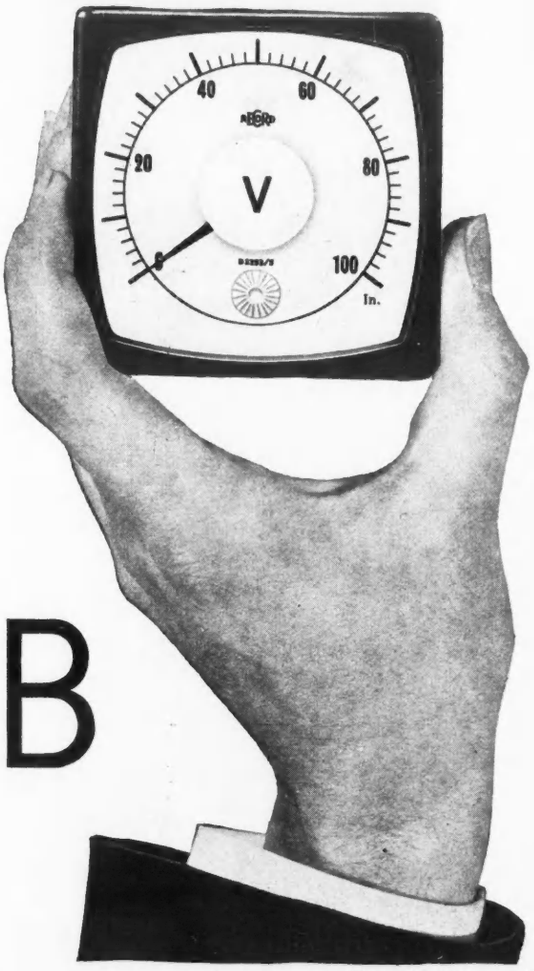

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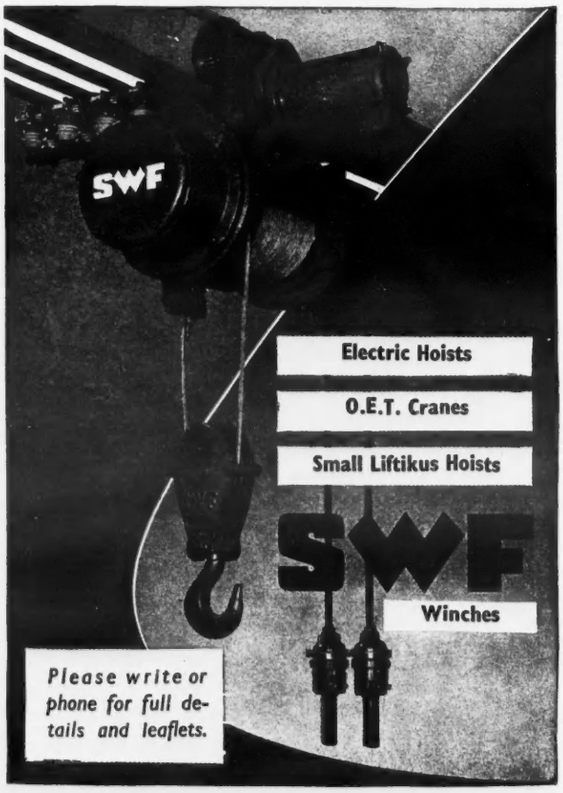

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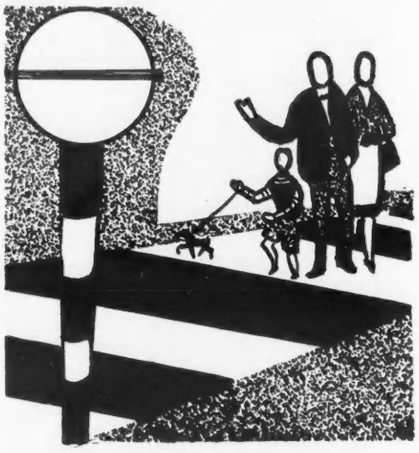

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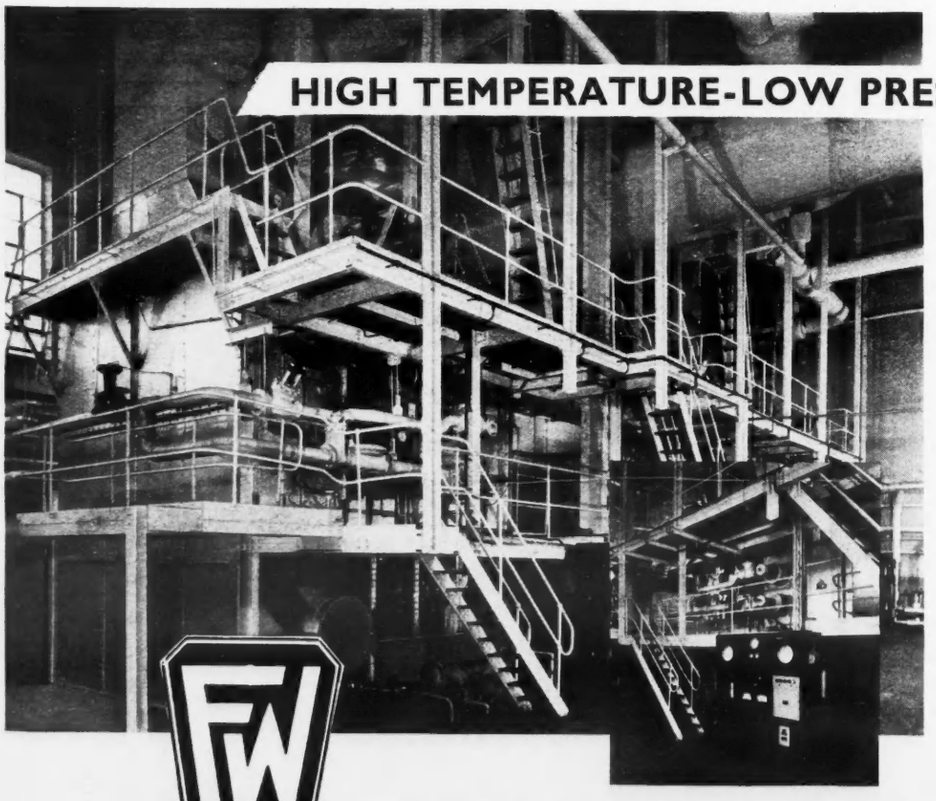

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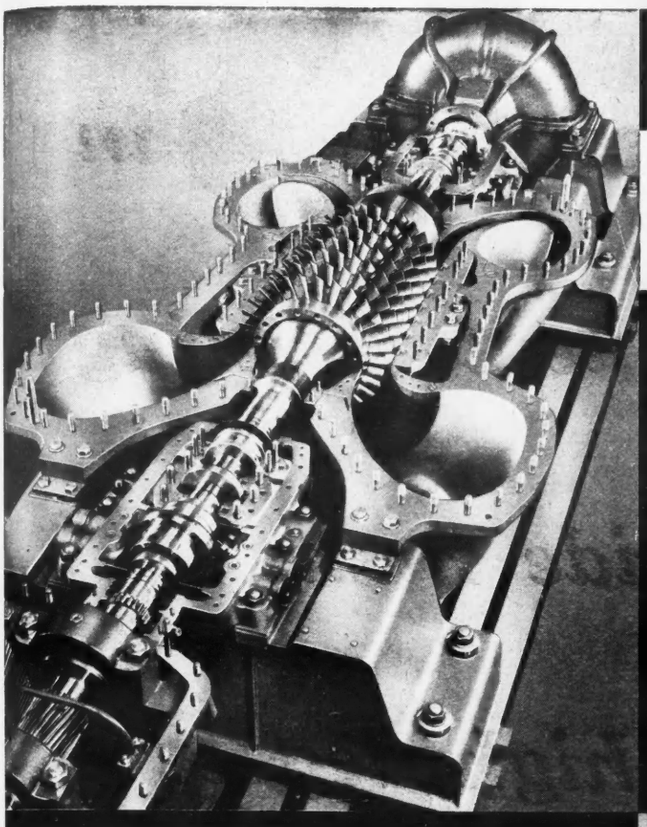

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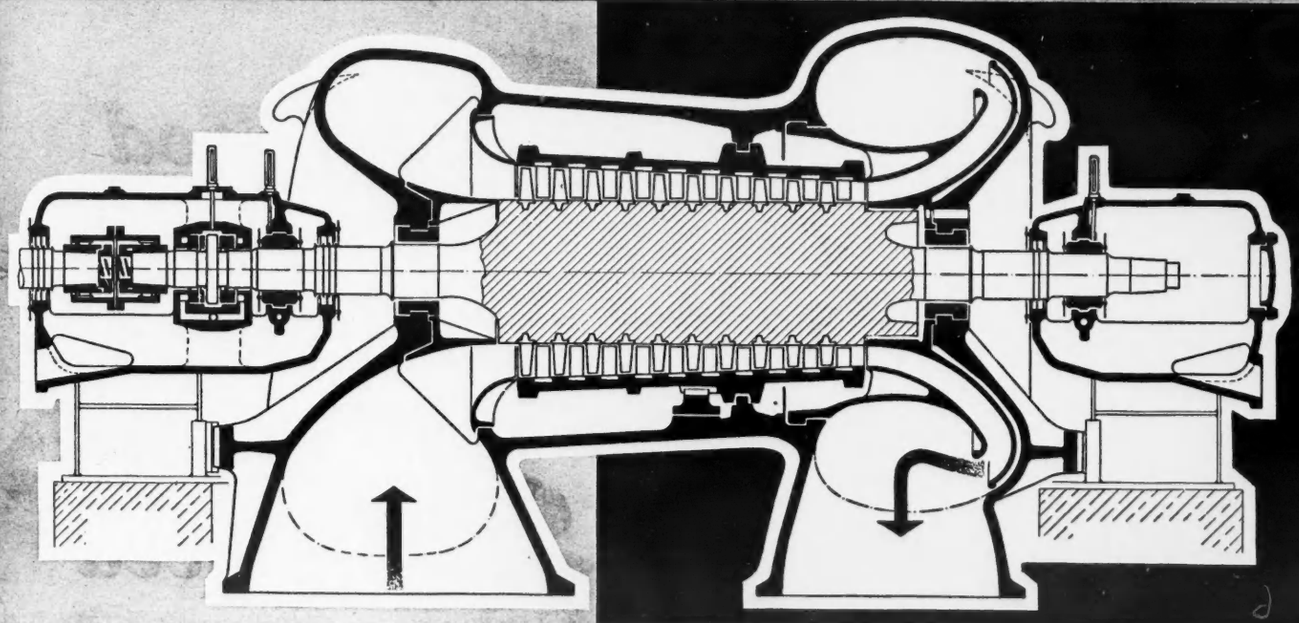

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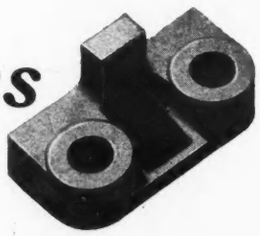
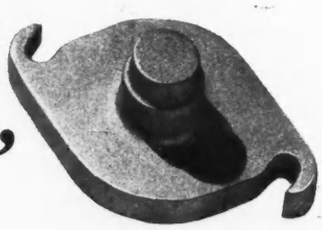
Shell Moulded Castings *in stainless and* *heat-resisting* *steels provide many advantages*  *– high degree of uniformity,*  *good surface finish, dimensional* *accuracy and* *reduced* *machining costs.*

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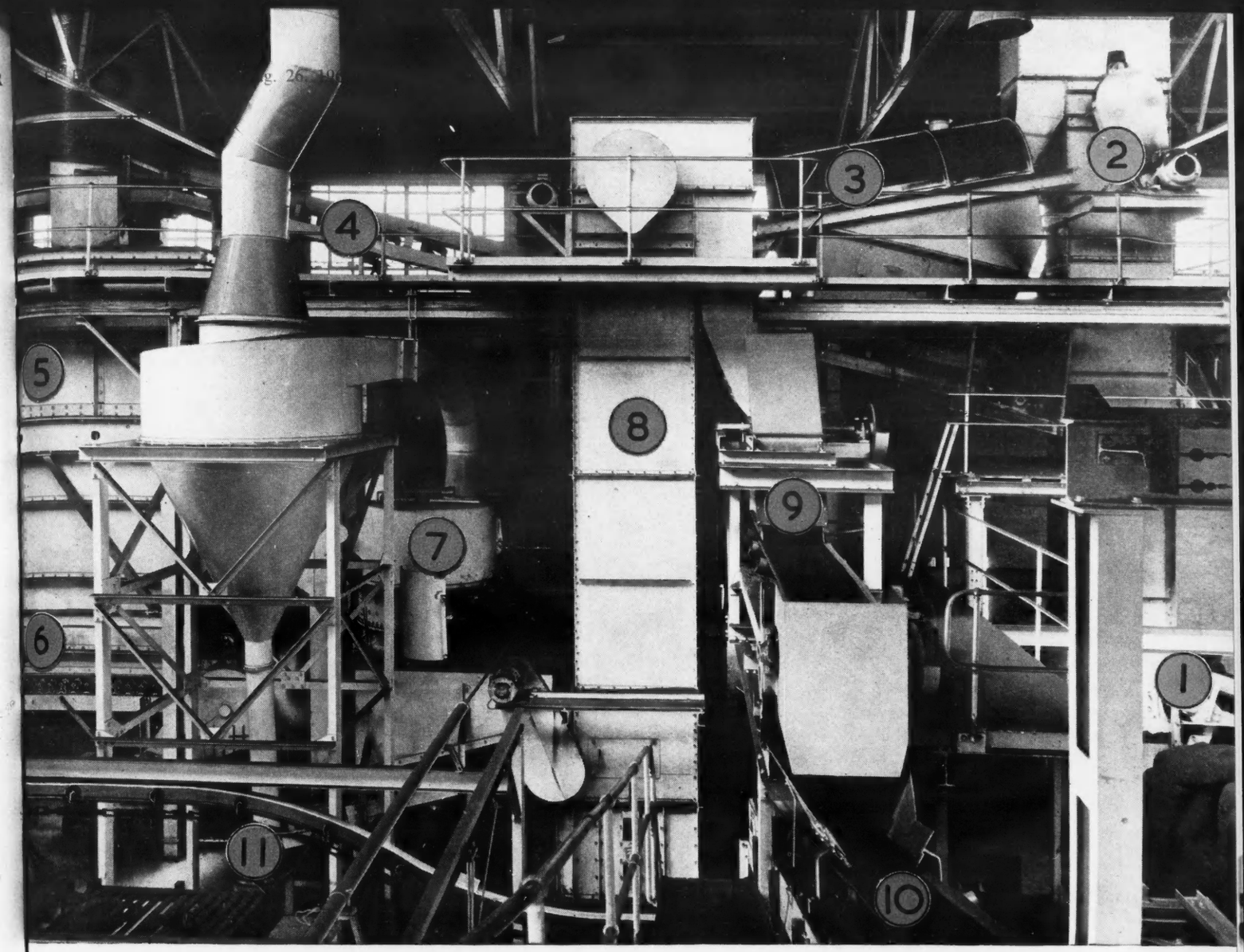

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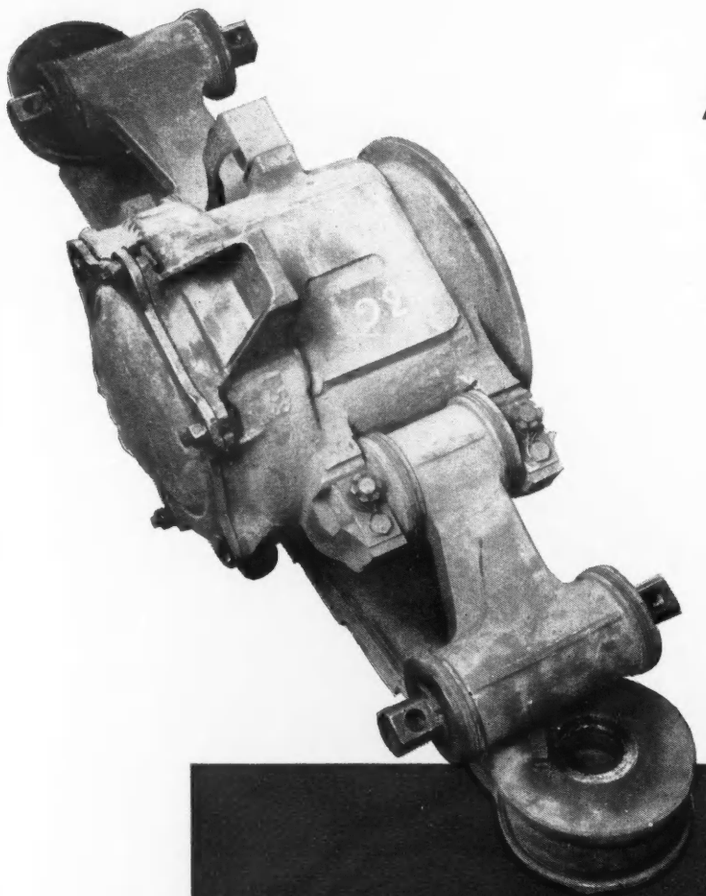

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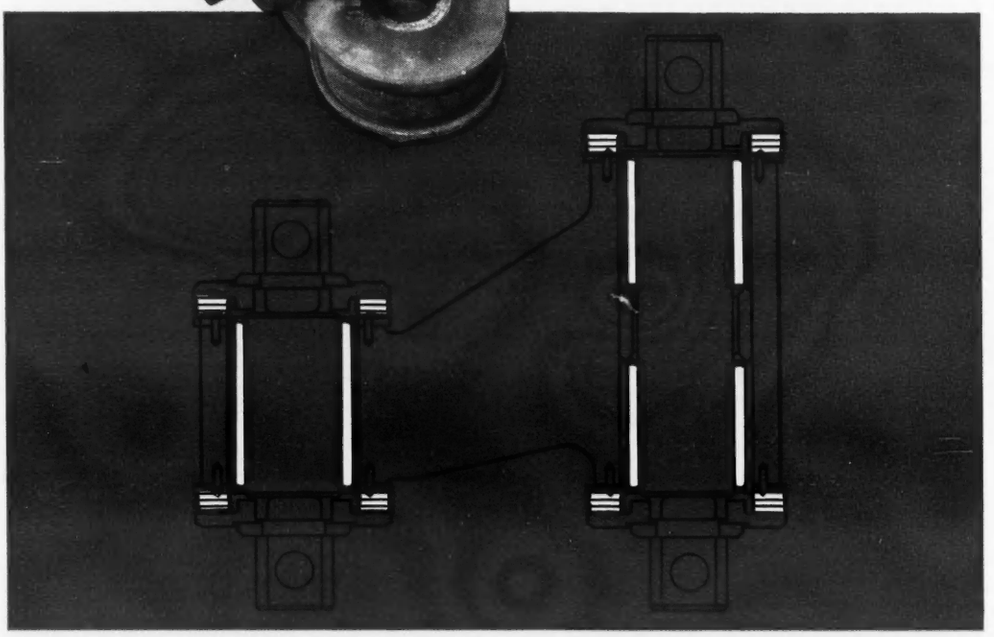

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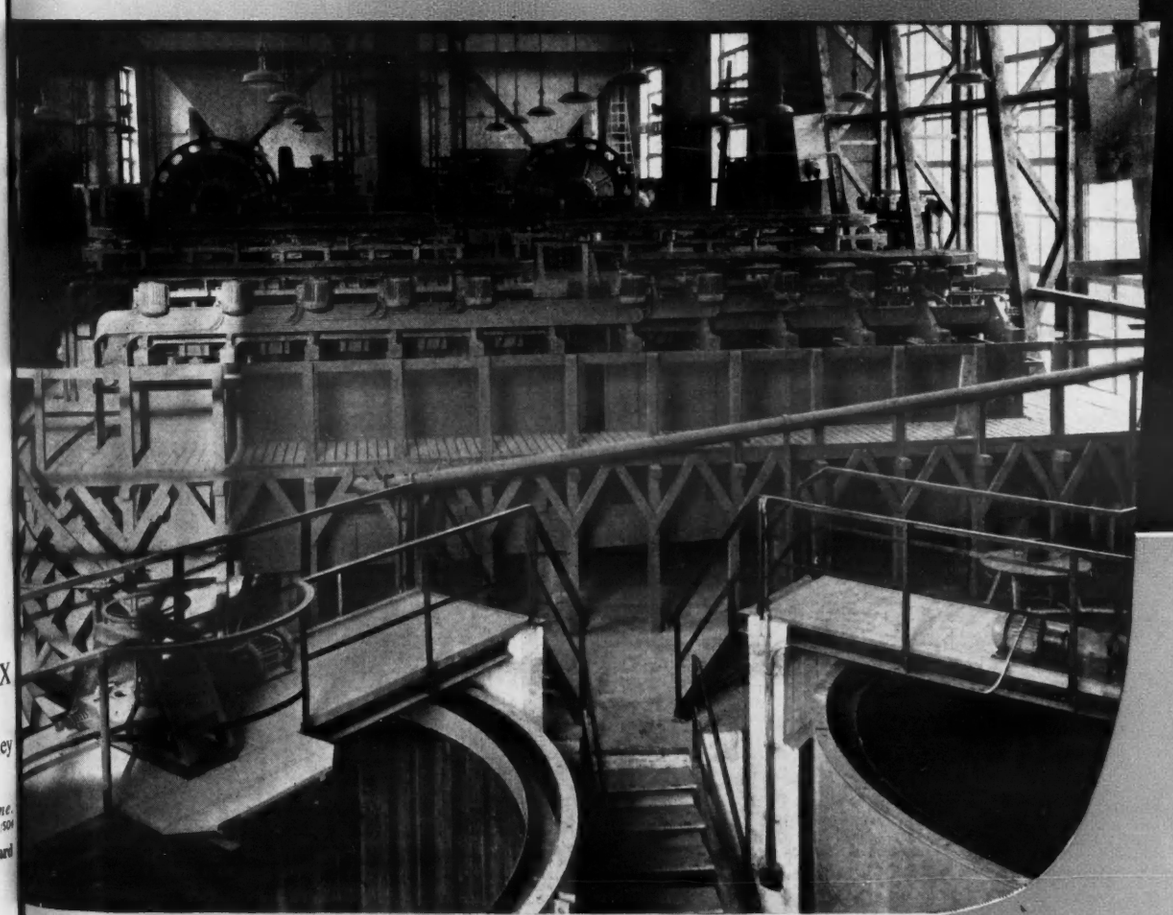

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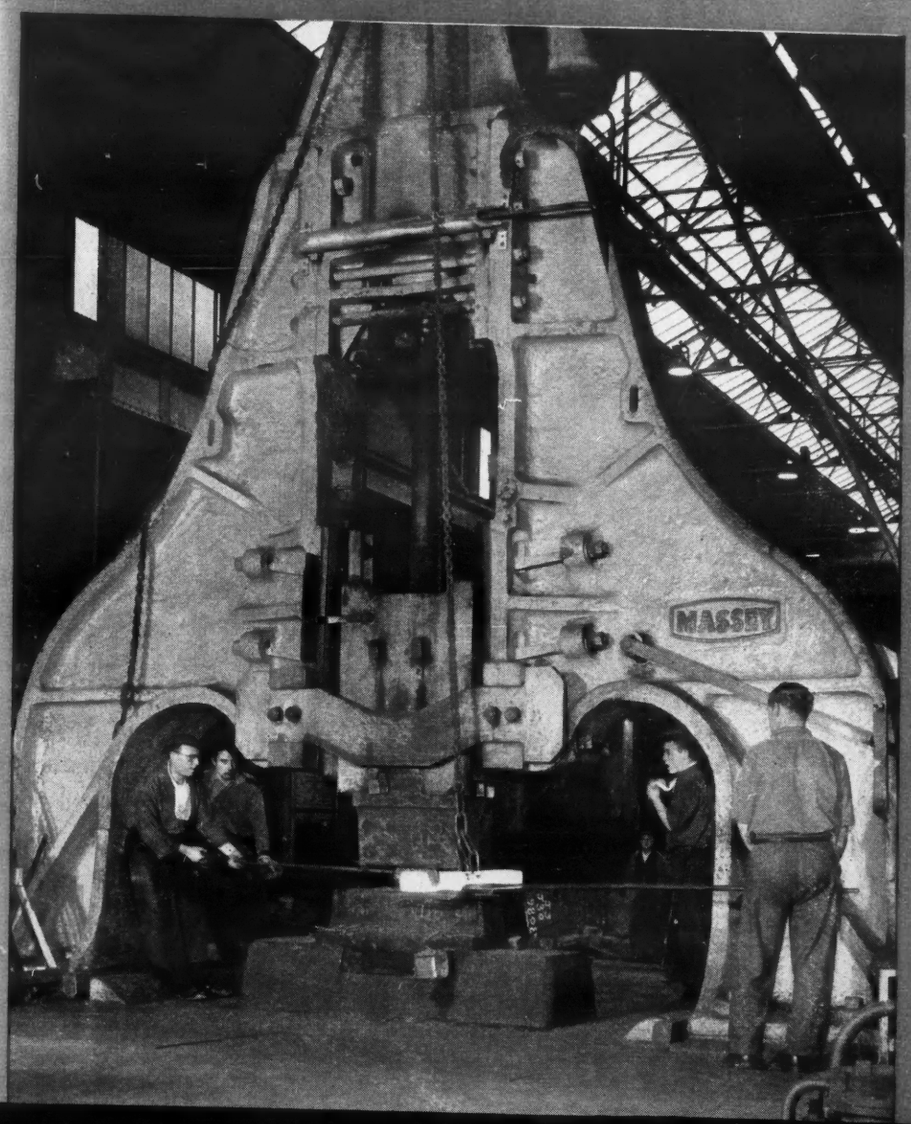

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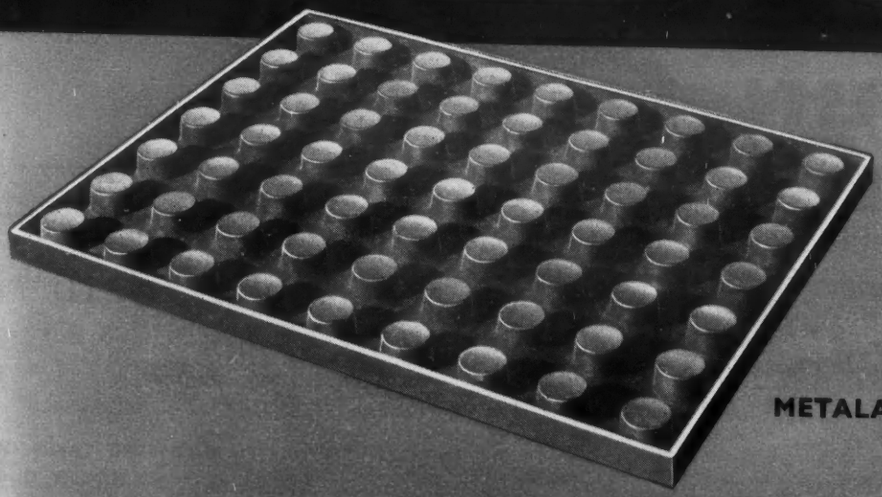

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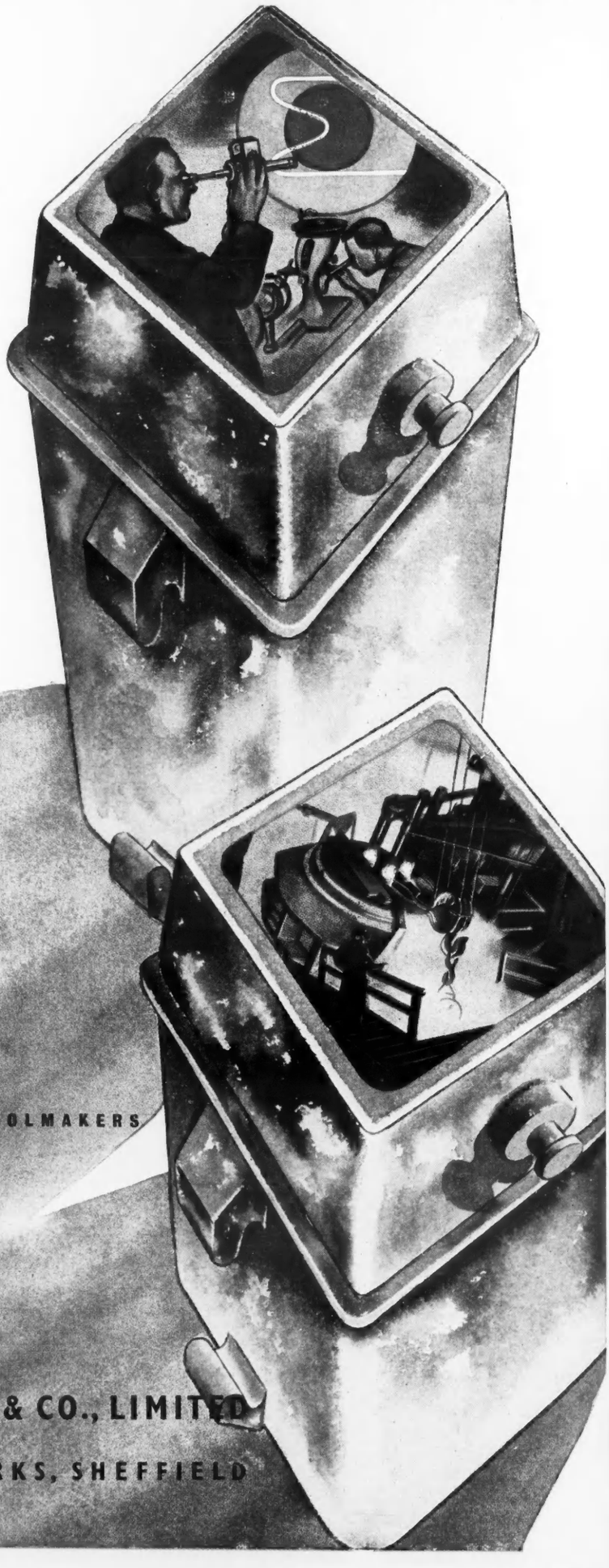

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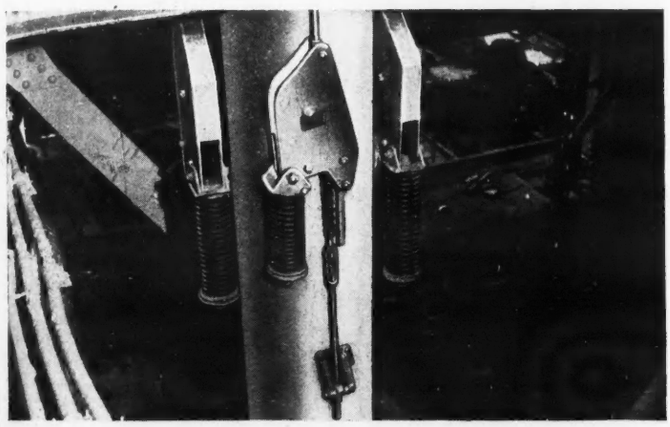

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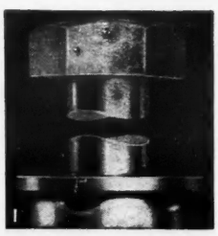

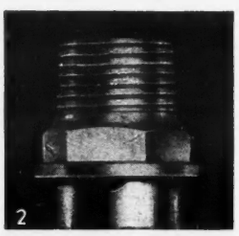

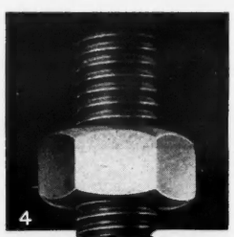

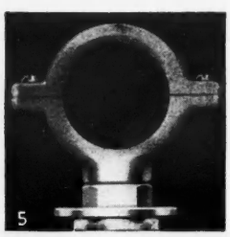

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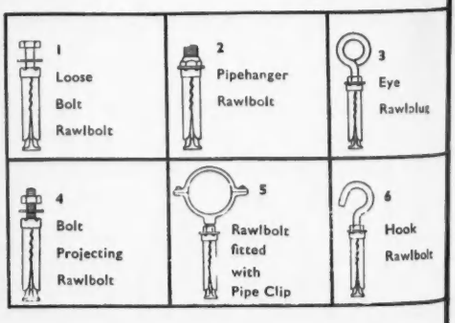

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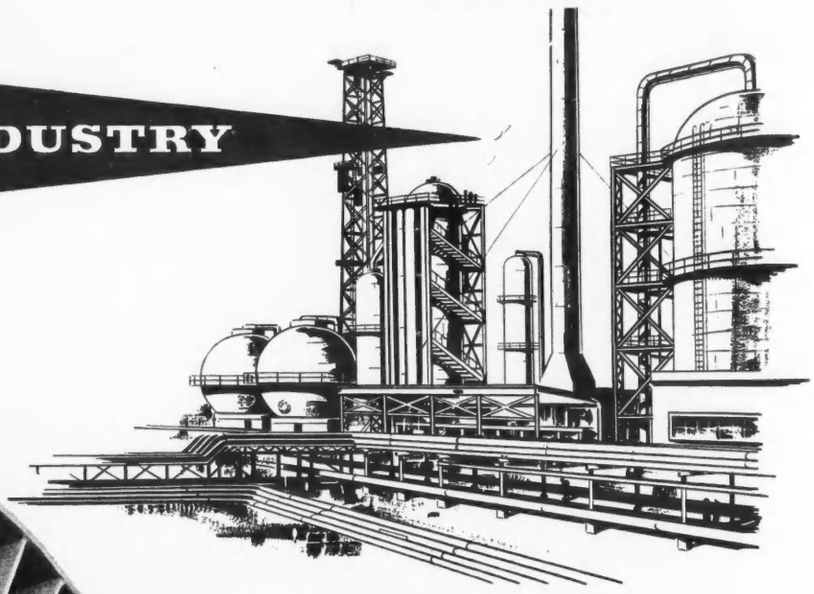

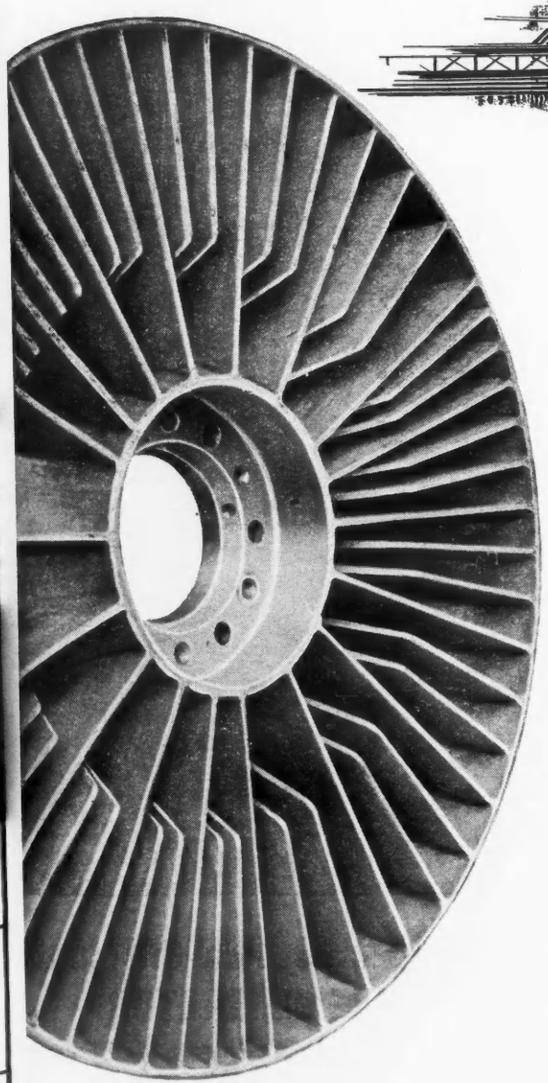

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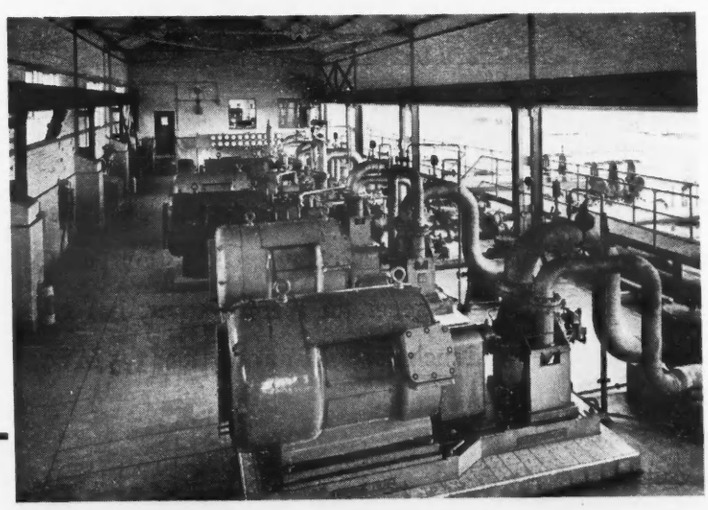

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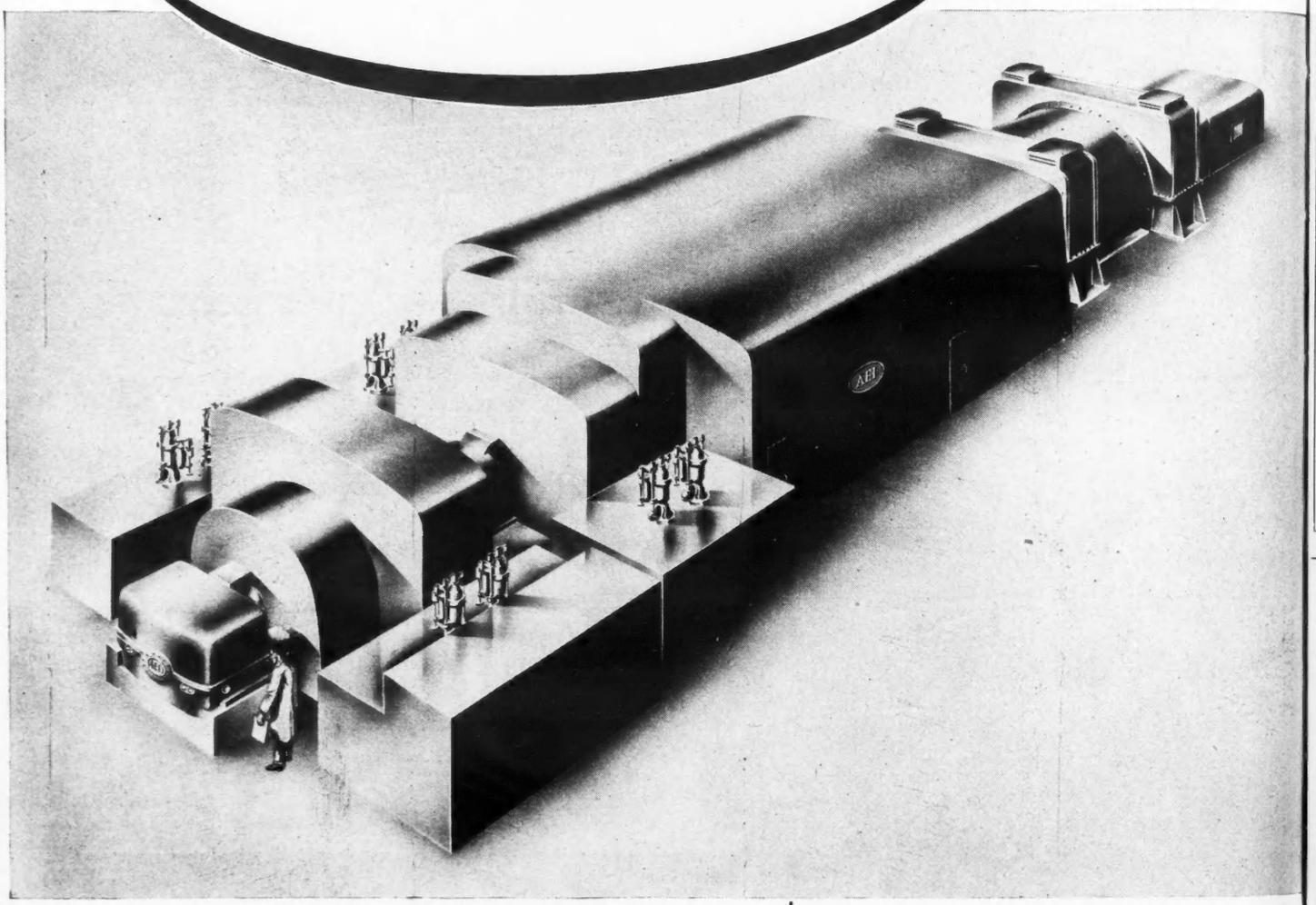

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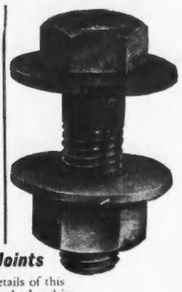

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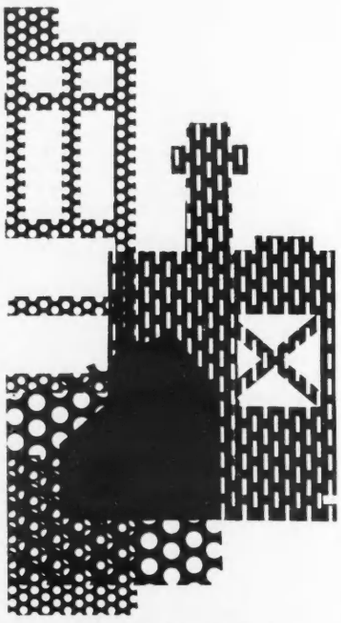

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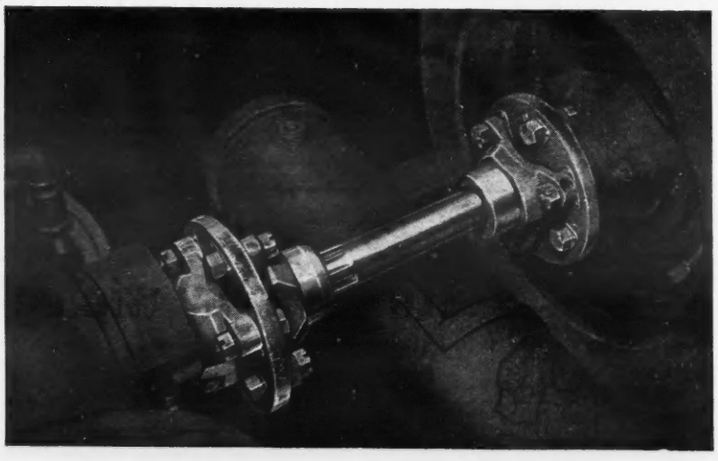

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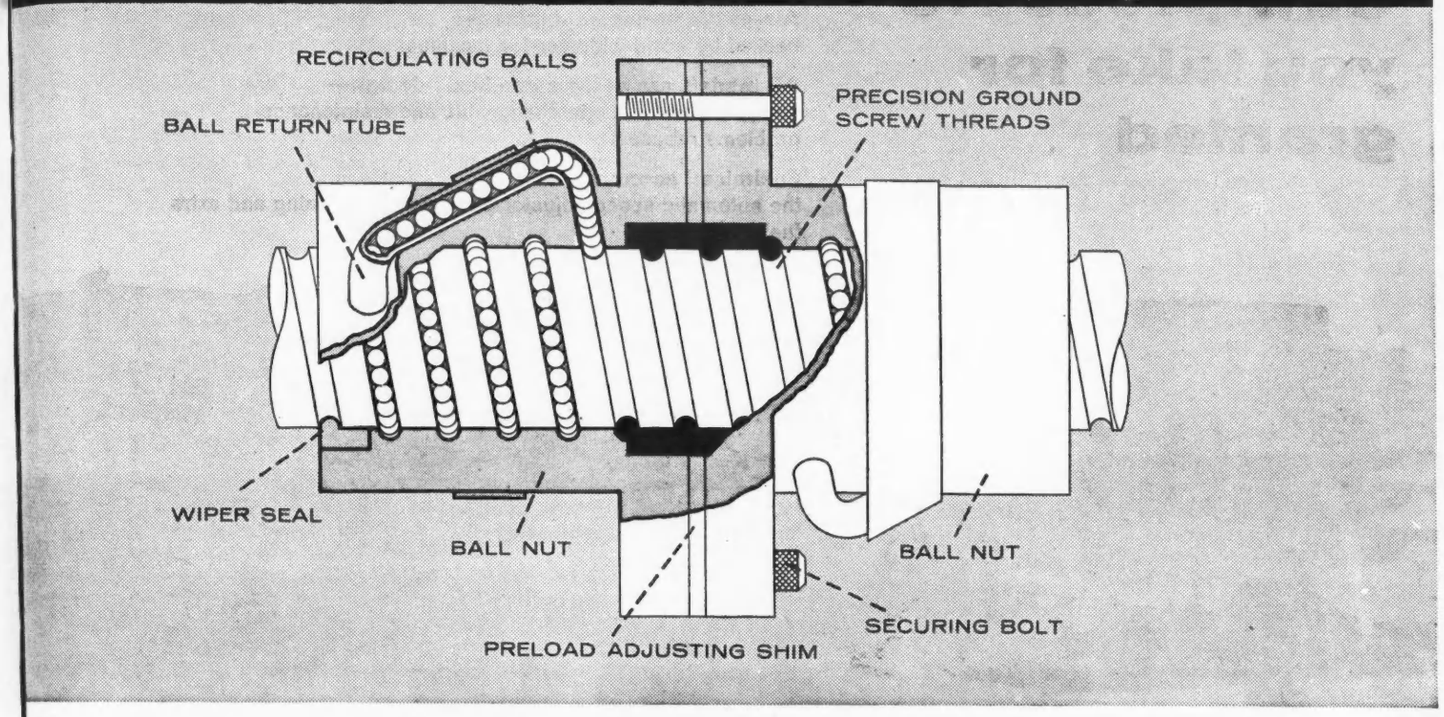

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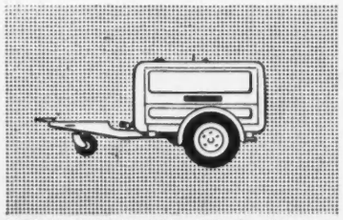
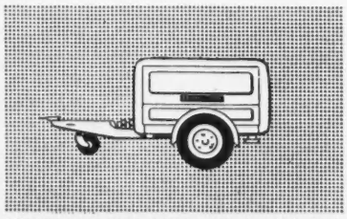
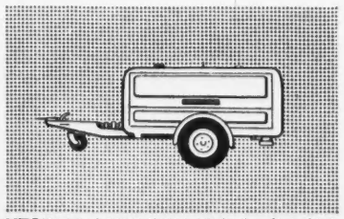


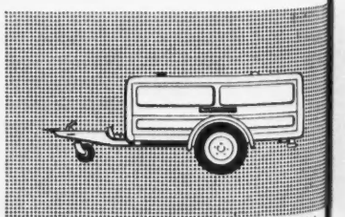
VT3 Weight 2,180 lb (990 kg) 115 c.f.m. (3.2m³/m)



VT4 Weight 2,310 lb (1050 kg) 160 c.f.m. (4.5m³/m)



VT5 Weight 2,900 lb (1315 kg) 225 c.f.m. (6.4m³/m)



VT6 Weight 3,590 lb (1630 kg) 315 c.f.m. (8.9m³/m)

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THE ENGINEER

No. 5457 AUGUST 26, 1960 Vol. 210

REPORT ON RESEARCH BY INDUSTRY

Though in this journal there are probably more references to the work of the laboratories of the Department of Scientific and Industrial Research than to that of the Research Association laboratories, it is no doubt the fact that contacts between industrial firms and the latter are more frequent and intimate than with the former. Support for that conclusion comes from the statistic that the number of research associations aided by the Department financially continues to grow and recently reached 50 through the admission to the scheme of the Water Research Association. Additionally we learn from an estimate in the report of the Industrial Grants Committee* that manufacturing industry spent on research and development 4·2 per cent of its contributions to the gross national product in 1958 as compared to 3·1 per cent in 1955, despite the fact that the share of defence contracts in the total expenditure went down. But if it is true that firms rely more on their association laboratories than upon D.S.I.R. establishments little harm is done because the former bodies are tending to accept close relations with the D.S.I.R. laboratories. As an example of this close collaboration the Industrial Grants Committee mentions in particular three areas of research in which it especially flourishes. They are research into creep, into the fatigue of metals, and into shipbuilding problems. On the subject of creep the National Engineering Laboratory, the National Physical Laboratory, and the British Iron and Steel Research Association are all involved. The first named has opened a "Creep Information Centre" from which industrial designers can conveniently obtain creep data, and which has as one of its objects the collection and correlation of creep data obtained from other establishments and from industrial firms working in this field. The organisation for research into fatigue is rather different. There, following up an initiative of the Institution of Civil Engineers, a committee has been set up under the chairmanship of Sir Alfred Pugsley to consider what researches need to be undertaken into the fatigue of engineering structures made of metal, to survey existing research facilities and to report to the Department. Its report is expected to appear this year. Amongst the nine members of the committee are representatives of NEL, NPL, and the British Welding Research Association, and it can reasonably be expected that co-operative research will develop as a consequence of its work.

Much criticism has been expressed during the last few years of the scale of the research of the shipbuilding industry. Some of it has been misinformed or based on misleading figures. We doubt, for example, whether the critics have always appreciated that there are three bodies active in this field, the British Shipbuilding Research Association, Parsons and Marine Engineering Turbine Research and Development Association, and the NPL, the latter recently equipped with a new ship hydrodynamics laboratory at Feltham. The quip we recently heard that PAMETRADA has become merely the turbine design office for the shipbuilding industry has, of course, a grain of truth in it. It was meant unkindly; but it can be accepted with pleased equanimity by the laboratory. For if design is to prosper it must go hand in hand with development and development frequently leads to the need for research. That PAMETRADA designs are so much welcomed is a tribute in reality to the value of PAMETRADA research and development. In this field the Grants Committee feels it to be "clearly important that the accumulated resources of all three research organisations should be used to the full in the future technological development of the shipbuilding and allied industries."

In addition there are welcome signs of a still growing recognition by Association laboratories of the need to keep well in touch with members and to convey to them the results of researches. The "mountain", it is better realised than it was, is not very good at coming to "Mahomet" but will often offer a fine welcome if "Mahomet" does the calling. Grants have been made to help with the extension of research associations' information services and the organisation of conferences, courses, film shows and the like. In this field the British Iron and Steel Research Association is even providing an advisory service in ergonomics and human problems. The recent tendency for research association staff actively to go out to offer their services to the industries which support them, instead of waiting for the questions to roll in is, we feel, much to be welcomed. For if it is important that industry should be aware of what research workers can do for it, it is just as important that those who work in research establishments should be properly in touch with industrial conditions and should have some understanding of design problems.

*Research for Industry 1959 H.M.S.O. Price 8s. net.

ANOTHER "FIRST" IN SPACE FOR RUSSIA

Though it is probable that the Americans are making a larger contribution to upper atmosphere research than are the Russians, it must be conceded that it is the achievements of the latter which repeatedly catch more limelight. Sometimes the Russians have caught the world's notice by achieving a remarkable "first" as, for example, in photographing the other side of the moon; sometimes they do so by the political or technical timing of an event. An event of last week, by accident, or design, was timed to show how great is the lead of the Russians over the Americans in rocketry. There is nothing very remarkable about sending animals into space nowadays. The Russians are believed to have sent dogs on many rocket flights of the ballistic variety and to have recovered some of them; and two monkeys, "Able" and "Baker", acquired fame when the Americans performed a similar experiment. A dog, "Laika", has been in orbit before, though the Russians were unable to bring it back again to earth alive. The Americans only a fortnight ago recovered a

" capsule " which had orbited the earth several times and they repeated the feat almost immediately. The Russians have now done the same thing. "Rocketeers" in both nations have therefore found solutions to the problem of re-entry into the atmosphere. But, an example of superb "one-up-manship", the capsule the Russians recovered, instead of weighing only some 300 lb., like the American examples, is reported to have weighed 4½ tons ! Furthermore, instead of instruments alone, it contained two dogs, both of which apparently survived the experience unharmed. In addition there was a minor menagerie on board of rats, mice and flies, not to speak of plants and fungi.

The special significance of the event, of course, is that the Russian capsule was large enough to have contained a man. Moreover, the survival of the dogs suggests that a man could have survived the experience too. In short the Russians have proved themselves to have the equipment and the technical knowledge to place a man-carrying capsule in orbit and to recover man and capsule at will thereafter. What is not known in the West, however, is the reliability of Russian equipment. In American experience a quite high proportion of rocket firings are failures for one reason or another. Volunteers, no doubt, are being trained for space flight in Russia just as they are in America; and they would prove willing to make the attempt at any time. But in neither country, we imagine, will the experiment of sending a man into space be attempted until the odds against a failure of the equipment have been reduced to a reasonable level. But in this context what does 'reasonable' mean?

The probability is now clearly high that the first man to orbit the earth in a satellite will be a Russian and the Russians have acquired so substantial a lead in placing large objects in a variety of orbits that they are likely to gain a number of other " firsts " in space flight. But in watching Russo-American competition in space we cannot help being reminded of the pioneers of ordinary flight. The people who caught the headlines between the wars were Alcock and Brown, Mollison, Miss Amy Johnson, Lindbergh and others like them who successfully completed daring flights. But the man who did more probably than any other to convince ordinary people of the advantages of air travel, and thus to bring passengers to airlines, was Sir Alan Cobham who set out to prove, and did in fact prove, that by regarding discretion as the better part of valour and paying attention to detail flying could be made safe.

HELPING RURAL INDUSTRIES

On various occasions in recent years we have commented on the " new look " that has become increasingly apparent in some rural areas of this country as industry from overcrowded cities and towns moves into them. In some country districts, which a few years ago were considered to be almost off the beaten track, there may now be found modern, well-appointed factories which do not mar the landscape and which, in fact, frequently bring restored prosperity to the neighbourhood in which they are sited. But establishments of this kind, built generally under schemes that are now operating for the more effective distribution of industry and the relief of heavily congested areas, do not by any means constitute the whole of rural industry. There are numerous other small factories, workshops and boatbuilding yards in country villages and towns, many—but not all—of which have maintained their business for scores of years and are a traditional part of the localities in which they stand.

That businesses of this nature are not drifting into a backwater is made plain by the annual report of the Rural Industries Bureau, a copy of which we have just received. The Bureau, it may be recalled, was founded nearly forty years ago as a result of an inquiry undertaken for the Development Commissioners into means of obtaining advice and information of value in the development of rural industries. Its activities are in no sense confined to that which is sometimes dubbed the " arty crafty." Far from it ! The many aspects of the help given by the Bureau to rural engineering concerns are of particular interest. The report records that during the past year rural engineering businesses have enjoyed a full share in the national prosperity. Development and expansion, it is stated, have been the keynotes of a large proportion of the inquiries put to the Bureau, inquiries concerning increased production, new products, enlarged or improved premises, or a combination of those items. Workshop expansion often includes the installation of machine tools with which the men employed are not familiar. Consequently, several country engineering firms, having taken advice from the Bureau on the choice and suitability of equipment, call for instruction in its use. Six of the Bureau's engineering instructors have devoted a large proportion of their time to this important task over the past twelve months, the number of visits made actually exceeding 1,500. Then, too, various items of equipment which have come on to the market in recent months have been tested by the Bureau's experimental workshop so that first-hand knowledge may be gained as to their suitability for rural engineers. Furthermore, there are several rural engineering establishments which have been seeking advice on appropriate method and work study systems, and which have had a good deal of guidance on training and apprenticeship matters. These are just a few examples of the help given to country businesses by the Rural Industries Bureau. There are others. One of them deserves special mention as it relates to the important business of exporting. The report explains that the Bureau has recently strengthened its export advisory section, which is frequently called upon to provide information about all aspects of export procedure. The Bureau often finds that the main problem is to guide those firms which come within its purview from thinking in terms of home markets to tackling export outlets. But, we are glad to read, it also finds that once the procedural difficulties have been cleared, there is much greater readiness to consider likely overseas markets. In a time like the present, when the need for expanding the country's exports is pressing, the contribution of small firms is valuable. It is indeed encouraging to be reminded of the services rendered in this and many other directions by the Rural Industries Bureau.

WHO IS TO BLAME ?

In a little over a week, the Trades Union Congress is to hold its ninety-second annual session at Douglas in the Isle of Man. The presentation of the annual report reviewing the activities of the general council during the year will, as usual, play a very important part in the proceedings. But this year, there will come before it the report of an inquiry by the council into the broad problem of disputes, workshop representation and related matters. That report should stimulate more inspired discussion than is usual at the Congress. For it contains much outspoken comment not only on the way-

wardness of employers but also on that of shop stewards; and some very harsh criticism of the way in which the Press reports their various activities. The report particularly takes the Press to task for showing "an obsessional interest with irregularities."

Trade unions do not seek immunity from criticism of their aims or methods, the report says, but it would be helpful if comment were better informed and if the information provided about industrial relations were less selective. Strikes caused by non-recognition of a union, by dismissals, by out-dated claims for managerial "prerogatives", and through managements breaking agreements or introducing changes without consultation, are given little publicity, the report complains; the responsibility of employers for strikes being largely ignored or played down by the Press. But the report goes on to say that trade union officers are not free from mistakes, and that in some cases the reason for a dispute developing into a strike may be a consequence of the representative's personality or his misjudgment of the situation. Speaking for the general council at last year's congress, it will be recalled, Sir Thomas Williamson said that there had been a number of serious unofficial stoppages of work, many of them on comparatively trivial issues, which could have been settled satisfactorily if machinery and procedure arrangements had been followed. The stoppages, he said, had been called by shop stewards in complete violation of the working agreements and in some cases before the executives of the unions knew that disputes existed. The report in front of us, engineers will be relieved to see, now emphasises that stewards who take action in defiance of their executives should be condemned, and union executives who fail to deal with them in such circumstances are not carrying out their responsibility to other affiliated unions.

Dare we suggest, however, that apportioning blame in this way, and listing the rights and wrongs of employers and employees may not be the best approach to the problem? Unless there has been a really serious failure of works relations, men come out on strike, official or unofficial, only when they feel aggrieved and dissatisfied. But often enough, we suggest, the apparent cause of the row, such as the dismissal of an employee, has little real connection with the sense of grievance. A greater awareness and understanding of each other's difficulties, blended with tolerance, would surely prove more helpful. It is suggested in the report that employees have a greater and more personal interest in industrial peace than have employers or managements. That is a point which is arguable. What is more disturbing is that the consumer is lightly dismissed. He may or may not be hurt, the report says. It is almost all it has to say on the point. But surely the consumer ought not to be dealt with quite so summarily? When industrial peace is threatened the issue is not always a straightforward matter to be dealt with between employees on the one hand and employers on the other. Both sides should keep the consumer well in mind when conducting their business; for ignoring him is tantamount to not feeding the goose which lays the golden eggs.

VALUE OF ROAD IMPROVEMENTS

Over the past few years Sir William Glanville, and several of his staff at the Road Research Laboratory, have on several occasions emphasised the importance of a realistic appraisal of the economic returns which can be expected from road improvement schemes. Their work has now reached the stage where what might be termed a "design method" has been evolved; this method is explained in the report "The Assessment of Priority for Road Improvements," by J. E. Reynolds, which has just been published (H.M. Stationery Office, 2s. 6d.). Engineers are accustomed to making economic assessments in any design which they undertake, but here we find the economic approach is rather different, and perhaps wider in scope than in any other sphere of engineering design. Briefly, the method involves the following stages: determining the cost of the improvement; forecasting changes in traffic flow, distance, speed and delay consequent upon the improvement; forecasting consequent changes in accidents; and then making a valuation of all these effects and a final calculation of rate of return. It can be inferred that the general use of this approach to road improvements will have a profound effect on the choice of future schemes, for of the four examples worked out in detail, the rate of return has been calculated to vary from 15 per cent in one case to 380 per cent in another. In very general terms, the report stresses that the maximum possible benefit from funds invested in road schemes will not necessarily be realised, even using this type of assessment, until a full survey of road needs has been carried out, thus making certain that there are no potential improvements more profitable than those actually selected. The method is better suited, it is considered, to simple road improvements than to complex urban improvements where secondary effects may be substantial, but further developments in the method are possible, and its publication is clearly an important step in establishing a more rational approach to this important subject.

The Engineer—100 Years Ago (AUGUST 24, 1860)

"Transatlantic Air Ships"

"The preparations are nearly completed in New York for the departure for Europe of Professor Lowe and his associates in his aerial ship. Professor Lowe is receiving the co-operation of several well-known commercial and scientific gentlemen, who, if not sanguine of the complete success of the expedition, are anxious to see the experiment of aerial navigation fairly tried. Whether successful or otherwise, it will probably add something to the general stock of scientific knowledge; and every precaution is being taken to secure the safety of the passengers. A trial trip has already been made with a successful result. This trial proves the possibility of directing the course of this ship through the air; and, as the general direction of the current of air is eastward at a certain distance above the earth, the probability of Professor Lowe's reaching Europe is very strong.

"Should this European voyage be accomplished in the short space of forty-eight hours, as the Professor anticipates, it will make a complete revolution in the manner of conveying intelligence between the two continents, as advantage can be taken of this eastward current, in the return voyage, by passing round the world. Though this subject is at present exciting little public attention, should this ship prove a success, the originator will rank among the world's greatest inventors. The name of this novel ship is the Great Western. Its extreme length or height is 300ft, its largest diameter 135ft; the basket in which the mail and passengers are to be conveyed is 30ft diameter, and constructed to carry twelve persons. Under this basket is an iron lifeboat 40ft long, which contains a caloric engine, which is designed to give the direction to the ship by moving a fan, rather than to propel the ship itself. Professor Lowe states that he will take letters for all parts of Europe, and promises to deliver them safely within two days. The proposed crew of the Great Western is Professor Lowe, two scientific associates, and an experienced sea captain to command the boat, in case it might be necessary to change the aerial for water navigation."

"Dragon" High-Temperature Reactor

No. II—(*Concluded from page* 306, *August* 19)

The first annual report of the O.E.E.C. High-Temperature Reactor Project known as "Dragon," published this month by the European Nuclear Energy Agency, gives a very detailed account of progress in 1959–60. *"Dragon" is a joint venture; its main objectives are to investigate the high-temperature gas-cooled (H.T.G.C.) reactor system and, specifically, to design, build and operate a* 20*MW (thermal) H.T.G.C. reactor experiment at the U.K.A.E.A. Establishment at Winfrith, Dorset. The following article is based on extracts from the report.*

A NUMBER of improvements have been made in the design of the fuel elements. The two most recent versions are designated Mark 6 and Mark 7, which differ markedly from the earlier proposals, in the design of the bottom end; also they differ from each other in the fuel rod pitch and in the fuel box which is included in the Mark 7 design. For the first charge of the reactor it is probable that the fuel element will resemble the Mark 7, although minor design changes are likely to continue. In particular, tests are in hand to give more information about the effects of dimensional changes of the fuel inserts on the mechanical performance of the fuel box.

The Mark 7 fuel element (Fig. 5) has a rod pitch of 2½in and a core length of 63in. The main design change apart from the rod pitch is the inclusion of fuel boxes to contain the fuel inserts and spine and a compensating bellows integral with the lower cap. The fuel box has three main functions. First, it is to be made of fine-grain graphite, suitably impregnated to delay the escape of volatile fission products for an hour or more and thus to lighten the duty of the external plant for cleaning-up the fission products. Secondly, the fuel box should give some protection to the main fuel element tube by preventing excessive fission fragment damage. Thirdly, the box is expected to give permanence to the purge flow gap which has been reduced to a nominal 0·005in, and to contain the fuel inserts in the event of any tendency to break or crumble.

The main function of the bellows is to minimise stresses induced during brazing of the graphite fuel tube to the metal cap nut. Therefore, the thinnest possible wall should be specified for this duty; trials suggest that a wall thickness of about 0·012in should be both adequate and attainable. The spring force associated with this single convolute bellows is about 4 lb or 5 lb per 0·001in deflection.

As in the earlier design, the seven tubes in each cluster are oriented by dowels in the top block and secured by through bolts with yield washers, but the assembly is strengthened.

Considerable difficulties have arisen in the manufacture of graphite suitable for impregnation, in the sizes required for the project, namely 6ft 6in long by 3½in diameter. Hitherto the bulk of the material used in connection with the project has been made by the Morgan Crucible Company, Ltd., Battersea, based on the firm's own research and development programme to produce material in accordance with the project specification. However, a major disadvantage of this material is that it contains significant quantities of boron.

Although exploratory experiments had indicated that this boron content could be controlled, preliminary production runs have shown this control to be impracticable. Analysis of these experiments has shown that the major boron pick up is in the graphitising stage of manufacture and it is now intended that the Morgan Crucible Company should supply material in the baked stage which would be graphitised elsewhere to give a material having a boron content of about three parts per million or, alternatively, treated in a purification furnace to give a nuclear grade material.

Purification experiments are being carried out by Société Pèchiney, Paris, using a treatment similar to graphitising. However, dimensional changes have been observed in the product and the process, therefore, requires further study. The other possibility—the graphitising of the Morgan Crucible Company's baked material in the form of rods—is being explored at A.B. Svenska Grafitvärken, Trollhätten, Sweden.

A possible alternative material that may prove to be suitable for impregnation is made by Siemens Plania, Griesheim, Germany. But this company's material, known as "Sigri" grade E, has not yet been developed

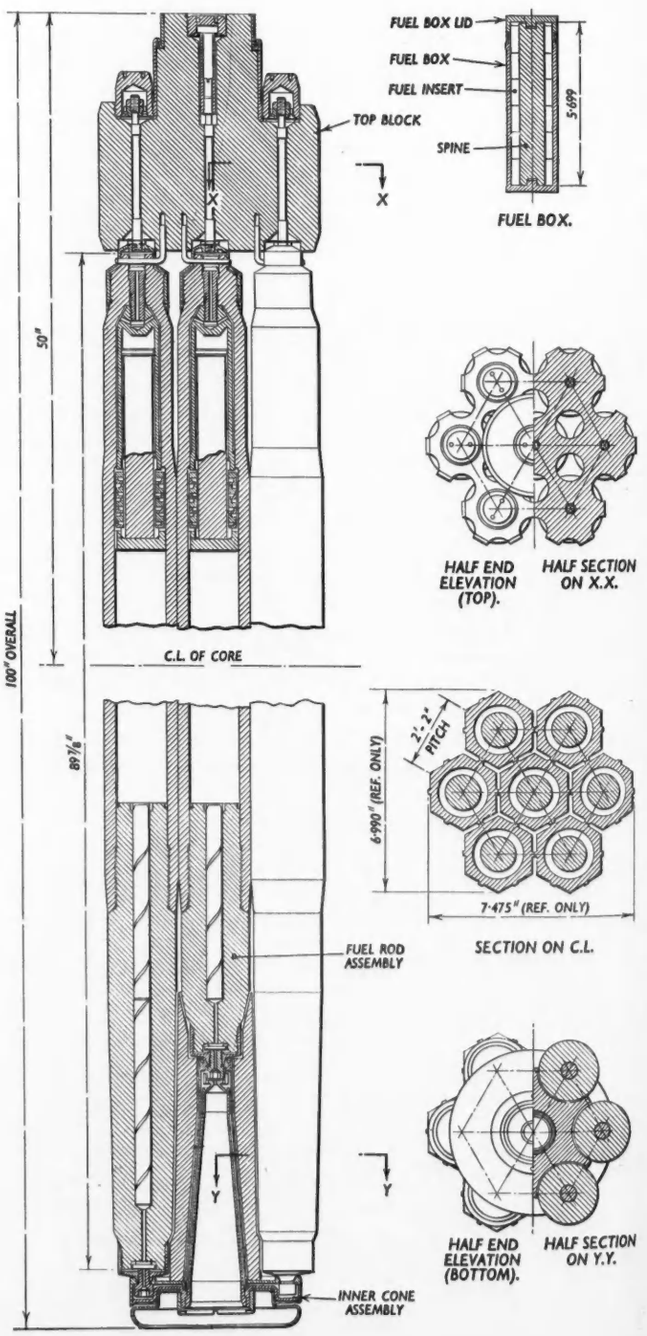

Fig. 5—Mark 7 fuel element assembly

to the stage where rods of the required length and diameter could be supplied. Nor has the suitability of this material for impregnation been proved. It is considered unlikely that the material will be ready for use in the first phase of the " Dragon " programme.

The favoured process for impregnating graphite to reduce its permeability under reactor conditions involves the use of furfuryl alcohol. In this process the pore size distribution in the graphite is of prime importance. Graphite with properties appropriate for impregnation has been produced in experimental quanitites by the Morgan Crucible Company, but difficulties have been encountered in making the larger sizes required and considerable development will be needed. In the meantime work is in hand to devise methods of impregnation that will be suitable for those graphites that have pore size distribution far short of the optimum.

Graphite/Metal Joints.—Exploratory work to develop a satisfactory graphite-to-metal bond has shown that a good joint can be made at the bottom of the fuel rod end, between the graphite and the " Nilo 40 " end cap. The preferred method involves brazing under vacuum at 950 deg. Cent. using a silver/copper brazing alloy containing titanium. Some designs have been tested and the work is now in the final stage of development.

Fissile and Fertile Material.—A survey of the uranium-thorium system has suggested that it should be possible to use uranium-thorium as a dispersed phase alloy rather than individual particles of the two elements. It is proposed to use them in the monocarbide form, in which form they are completely miscible. Equipment to produce this material is now being developed.

Fuel Inserts.—Apparatus to fabricate fuel inserts by cold compacting graphite powder and the appropriate metal or carbide powder is being set up at Winfrith.

Work on inserts for retaining fission products at Harwell and at R.A.E., Farnborough, has proceeded during the year. The Harwell process involves reacting uranium metal to form the hydride (which produces a fine powder), and further reacting this hydride with hydrocarbon to convert the metal powder to carbide and subsequently to deposit a coating of pyrolitic carbon around each particle by further reaction with the hydrocarbon. In the R.A.E. process, a solution containing the fissile and fertile material is absorbed in cellulose fibre which is subsequently dried and carbonised. This carbonised compact is impregnated with pyrolitic carbon, and exploratory irradiation results have indicated that such a process is worthy of development to provide a fission-product-retaining insert.

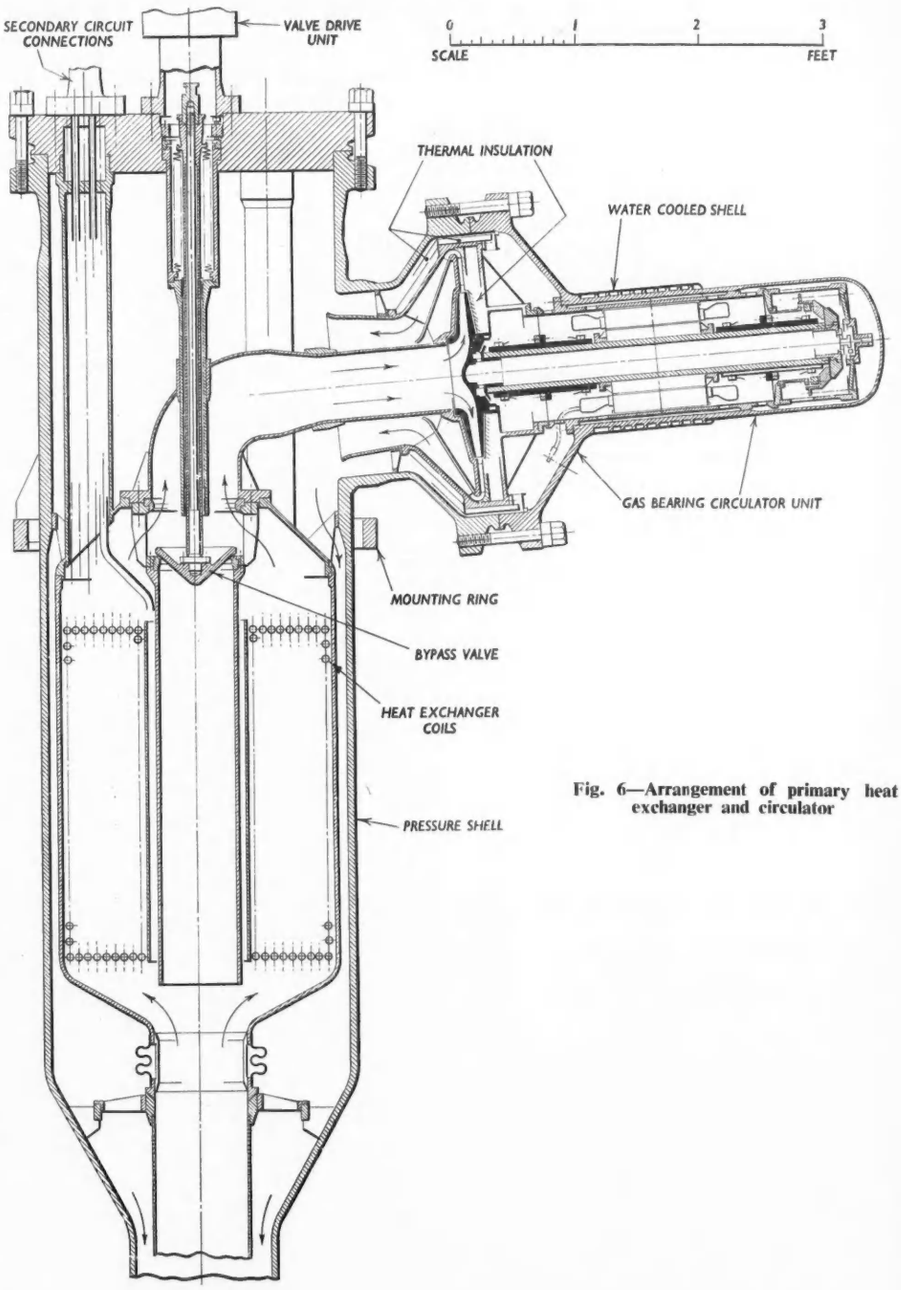

Fig. 6—Arrangement of primary heat exchanger and circulator

Reactor Control System

Full control of reactivity will be achieved by absorber rods lowered into holes in the removable reflector blocks, just outside the core. For emergency shut-off the rods will fall into the reflector under gravity. Additional reactivity control will be available by means of graphite moderator rods which can be lowered out of the core ; they will also fall slowly under gravity in the event of an emergency shut-down or power failure, although this provision is not essential for safety.

There are twenty-four absorber rods with identical operating mechanisms arranged, with six gaps, at thirty equal intervals, the gaps being occupied by instruments. Each rod consists of a stainless-steel sheath packed with boron carbide and is suspended on a stainless-steel wire cord which passes down a steel tube to protect it from the hot gas in the plenum chamber. A small flow of gas at 350 deg. Cent. enters the shield tube at the top, flows along the cord and absorber rod and leaves at the bottom of the hole in the reflector. To avoid jamming, the outer diameter of the absorber rod is only 2½in, while the bore of the tube and of the hole in the reflector is 3in. The drive to the cord is by a motor, through a 6 : 1 gearbox, a transverse shaft, and bevel gears in a " winding head." The cord passes round a pulley on the absorber rod and the upper ends are wound on to two symmetrical grooved pulleys to keep the rod in the centre of the tube bore. The transverse shaft is driven by an overwind mechanism in which a differential bevel gear accepts input from either the motor-driven gearbox (normal operation) or from a handwheel (maintenance). A flywheel on the gear drive accepts the energy from the absorber rod at the end of its fall under gravity during emergency shut off ; a free-wheel enables the flywheel to run down by incidental friction and windage. The gearbox also contains limit switches, mechanical limit stops and a transmitter synchro position indicator. The motor is a " stepping " motor : it is a development of the light-load follower motors used in compass systems. In its present form, made by The Sperry Gyroscope Company, Ltd., Brentford, Middlesex, it has a 5 lb-ft breakaway torque. It is reversible and can be run at 10 or 1·25 r.p.m. The rotor can be " locked " in any position or can be released to run free and allow the absorber rod to fall; failure of the power supply frees the rotor. A transistor circuit controls the motor.

Charge Machine

The charge machine is permanently housed in the upper part of the reactor pressure vessel above a shield plug in the neck of the vessel. This region is supplied with a small flow of primary circuit gas which has been cooled to about 50 deg. Cent., thus keeping the charge machine at a low temperature. Then, before returning to the reactor, the

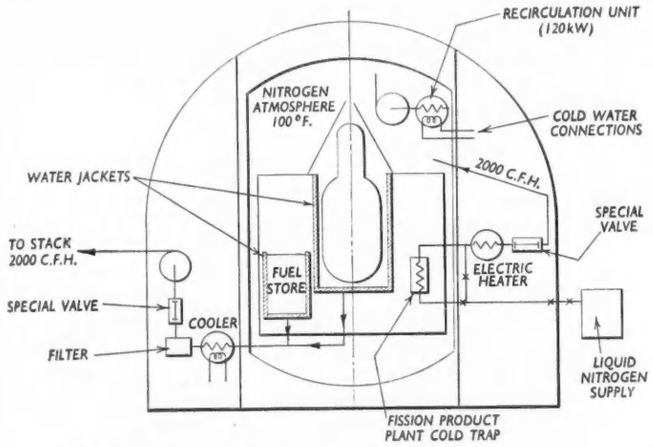

Fig. 7—Diagram of inner containment ventilation system

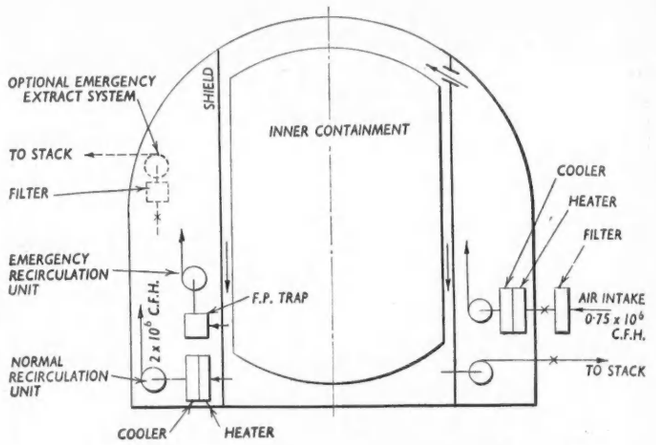

Fig. 8—Diagram of outer containment ventilation system

gas flows through the shield plug to cool it. The decision to house the charge machine in the pressure vessel was reached after a full study of the alternative—a removable machine. The latter would have required heavy shielding and the additional loading would have caused structural complications ; because of the active gas circuit awkward decontamination problems would have attended the making and breaking of seals to the charge machine ; in addition, heavy lifting tackle would have been required for moving the machine.

The main disadvantage of the built-in charge machine is that it is not readily accessible for servicing and higher reliability is therefore called for. However, the permanently known accuracy of positioning and subsequent operation of the built-in charge machine offers some compensation. In addition the loads to be carried by external lifting equipment are reduced to the small shield flasks for fuel elements, and the shielding round the machine can be built on the static reactor shielding.

At present the design of the charge machine has reached the final stages, although it requires more work on design detail. A test machine of earlier design has been erected at Winfrith and this is now operating with early type fuel elements. Results of behaviour are being fed into the final design and although it is not an exact counterpart of the present design it is providing invaluable information on performance. Control instrumentation to allow remote operation will be added so that the methods of operation control can be developed. In the charge machine, the items inside the reactor vessel enclosure consist almost entirely of mechanical transmissions using spur gears and rolling bearings with suitable grease retention. Each electro-mechanical drive unit is situated at an accessible external point outside a bulkhead containing a twin shaft seal. Normally, each assembly is contained in a further pressure enclosure or cover, but for maintenance access the enclosing cover can be removed without breaking the reactor seal. A safe barrier can be provided for maintenance occasions by pressurising the interspace between the shaft seals with clean helium. The mechanical transmissions within the enclosure will work at low loadings and have a very adequate strength margin. The running features, such as bearings and ball nuts, will have undergone considerable testing in representative conditions, and since the machine will be parked above the top shield plug in the cool upper end of the pressure vessel it is expected that long periods of operation can be obtained without servicing. The possibility of servicing has, however, been provided for.

To remove a fuel element the reactor must be shut down and fuel element shut-down heat allowed to decay for about twelve hours to eighteen hours. The charge machine grapple can then remove filler plugs from a central hole in the shield plug. These items are parked within the machine enclosure, and the grapple can be inserted and manipulated to remove the fuel elements. To discharge an element from the reactor it is first taken into the chamber above the shield where it is placed on a prepared receiving point. A can is placed over the element and attached to the base on which the element sits. The element, now in a sealed enclosure, is passed out through a gas lock for transfer to storage. Before storage, however, the " can " seal is supplemented by a soldering process between the can and its base. The design of this sealed can is at present receiving attention and a prototype is now going forward for manufacture. In addition, a drive arrangement for joining the two parts of a can is also being manufactured. To assist operations, provision is made to install television and optical viewing systems ; either or both can be used during the charge and discharge procedure.

Heat Exchangers

The primary heat exchanger design is influenced by the secondary circuit and three alternative schemes are being critically examined. They are : (1) boiling water evaporating system with natural circulation ; (2) boiling water evaporating system with forced circulation ; (3) non-boiling pressurised water with forced circulation.

The choice appears to lie between systems 2 and 3. System 3 requires smaller connecting pipes, but it needs both a pressuriser and a canned pump unit. Lower temperatures in the secondary heat exchanger demand a somewhat larger size of secondary heat exchanger and also a large size of cooler. A large output pipe is required in system 2 to take the steam-water mixture and there is some complication in providing for expansion. It does not require a pressuriser and the higher temperatures reduce the sizes of secondary units and cooler units. A canned pump is, however, required. This scheme is quite practicable and its margin of safety is probably higher than that of system 3.

System 1, although basically simple, has more practical disadvantages since it requires very much larger piping and contains greater volumes of water. This is inconvenient if the consequences of water leakage into the reactor are to be minimised. The ancillary piping for filling, draining and control may also be more complex than in systems 2 and 3.

The above remarks are based on present progress, but further examination in detail is proceeding, particularly on the behaviour under abnormal or fault conditions, so that a conclusive choice may be made. Fig 6 shows the proposed arrangement of a primary heat exchanger.

Primary Circulators

The six primary circulators are enclosed in the main pressure circuit, mounted adjacent to the top of each heat exchanger. Each circulator unit is driven by a three-phase induction motor. The primary circuit pressure enclosure embraces the whole unit and gas bearings are used to carry the rotor.

A diagram of the proposed unit is shown in Fig. 6. The motor can develop approximately 100 h.p. at about 12,000 r.p.m., which exceeds the full load pumping power requirement. All six units operate in parallel from a single variable-frequency supply giving speed control to cover reactor output down to about 10 per cent of full load. Although circulator speed controls the coolant flow, it is also necessary to provide a by-pass valve in each heat exchanger to permit direct control over heat exchanger performance so that the inlet temperature can be held. This valve can also be used to close off its circuit. It will then be possible to run the reactor at reduced output with a given circulator out of operation. It is, however, not intended normally to run the reactor in this manner. Failure of one circulator during operation would shut down the whole reactor. Under this condition, natural circulation will remove shut-down heat.

If the reactor is shut down when the circulators are running normally, the intention is to drive the frequency-changer set with a pony motor running at a low speed to maintain a defined shut-down circulation, although natural circulation will suffice. This would occur automatically, the pony motor being fed from the guaranteed power supply. If, however, shut-down is initiated by failure of one circulator, the pony motor drive will not take over automatically until the defective circulator is disconnected from the circuit.

Some proving tests are needed to determine the size of the gas bearings required for this unit and work is now in hand to manufacture a representative running assembly for tests at Harwell and Winfrith. The tests will be made in several stages, starting with simple tests in air, and will be extended later, using the initially manufactured parts, until a prototype unit as shown in Fig. 6 has been made and tested.

Containment and Ventilation

The whole primary circuit is enclosed in a nitrogen-filled shell, known as the inner containment. It is an all-welded steel shell designed to withstand an internal pressure of 10 lb per square inch gauge, at which the leak rate is specified to be not more than 0·1 per cent per day. Within the shell (Fig. 7) there are two shrouded areas, one surrounding the primary circuit and the other the fuel store. Nitrogen is drawn through these spaces to remove any fission products. The nitrogen flow (2000 c.f.h.) will be sufficient to reduce the concentration in the shrouded areas so that no significant activity can diffuse into the inner containment shell. This nitrogen purge flow will be cooled and filtered before it is discharged up a stack 60ft high.

Fresh nitrogen will be continually supplied from a liquid nitrogen plant or storage tank. Normally, the liquid nitrogen will be evaporated partly by the cold traps of the fission product removal plant and partly by an independent heater. Should any defect occur at the cold traps, however, they may be isolated and all the liquid nitrogen may then be evaporated in the independent heater, which also serves to heat the nitrogen gas to acceptable temperatures in normal operation. Both the inlet and outlet of nitrogen will be controlled by special valves which will automatically seal the inner containment building in the event of an abnormal rise in activity level.

Most of the heat leaking from the plant in the inner building will be absorbed in water which acts as a heat sink, e.g. in the thermal shield. It is expected, however, that about 120kW of heat will enter the nitrogen atmosphere and this will be removed by forced recirculation of the nitrogen through water-cooled heat exchangers.

The inner containment will be fitted with airlocks, one for vehicles and one for personnel. Since the volume of these locks is small it will probably not be necessary to purge them with nitrogen before allowing them to communicate with the inner space. A crane will be installed in the shell, capable of handling major components such as heat exchangers. This handling may be carried out remotely from behind the protection of a concrete wall which completely surrounds the shell.

Enclosing the inner containment is a concrete structure which forms the outer containment building (Fig. 8). Apart from acting as a general building for housing ventilating equipment, electrical distribution boards and small plant items, it also houses the charge machine control room and control points for crane and servicing operations. This building provides further shielding against radiation from an accidental release of fission products, and serves to control the leakage of activity from the system after a serious accident.

The outer building will be ventilated by a supply of fresh air which will enter via a filter and a heater/cooler unit. This air will be rejected via the stack after it has been recirculated within the building and passed through further heater/cooler units. This building is designed to withstand an internal pressure of 3 lb per square inch gauge and to have a leak rate not greater than 5 per cent per day at 1 lb per square inch differential.

In the event of an emergency, the normal ventilation air is stopped and the building isolated by valves. A recirculation unit incorporating a fission product trapping system is then started up. This unit draws air from space between the inner building and the surrounding shield, passes it through the trap and returns it to the outer building. In this way it is expected to reduce the activity leaking to the outer containment by at least a factor of five over that which would obtain if no such unit were used.

Consideration is also being given to the fitting of recirculation units inside the inner containment ; these would have the merit of more rapidly reducing the fission product activity, but would introduce problems due to the difficulty of maintenance, and also due to the heat generated by the fission products when they have collected on the filter units.

Study is also being made of the possibility of extracting air from the outer building through the filter to render the pressure there sub-atmospheric and in this way to control the leakage of activity. This system depends very much on the efficiency of the filter in the extract, particularly in relation to iodine. Such a system would enable a continuous check to be made on the leak-tightness of the outer building.

The outer building will not be fitted with airlocks, but will have a double door system, one part of which will be a sealed door unit. Personnel will only enter the inner containment when the reactor is shut down, when they will wear protective clothing and breathing apparatus. It is expected that no more than ten men would occupy the outer building.

The Mass Haul Curve

By F. BETTESS, M.Eng., A.M.I.C.E.*

The author considers that the theory of the mass haul curve as usually stated in surveying textbooks suffers from certain disadvantages. He suggests an alternative graphical procedure based on the familiar polar diagram and link polygon.

A BRIEF statement of the mass haul curve theory may first be given. In Fig. 1 let *ABCDEF* be the longitudinal section along the centre line of a road and let *ACEJ* be the formation line. The summation of excavation (positive) and filling (negative) from the starting point *A* is shown by the line *abcde*. If *b* and *d* are at

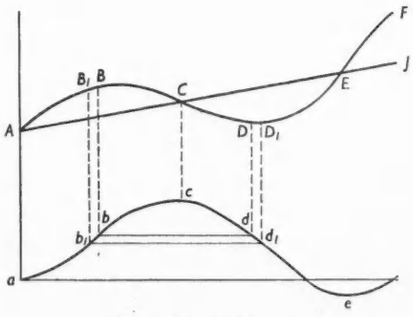

Fig. 1—Mass haul curve

equal distances above the base-line, then the totals of cut and fill up to *B* and *D* are equal, and so the amount of cut and fill between *B* and *D* must balance. Similarly, the cut and fill between B_1 and D_1 balance. Then the cut between B_1 and *B* is equal to the fill between *D* and D_1, and its volume is equal to the difference in height between *bd* and b_1d_1. In order that the excavation between B_1 and *B* may be used for fill between *D* and D_1 it must be moved a distance equal to the mean of *bd* and b_1d_1. Therefore the area bdd_1b_1 represents the product of volume transferred by distance moved.

If the free-haul distance is given as *L*, then on a mass haul curve, part of which is

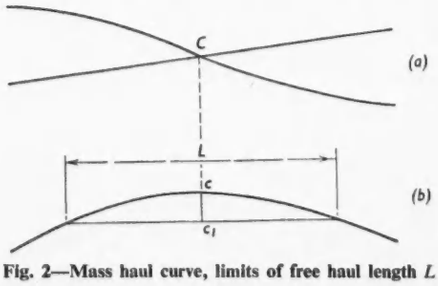

Fig. 2—Mass haul curve, limits of free haul length *L*

shown in Fig. 2, a horizontal line is drawn, just equal to *L* and just touching the curve. The height cc_1 represents the volume which is hauled free and material outside the line will all be subject to overhaul charges.

Example.—Consider the earthwork problem illustrated in Fig. 3 (*a*). From chainage 0 to 1000 there is uniform excavation and from chainage 1000 to 2000 uniform fill. For simplicity the volume of excavation or fill between successive stations is taken as unity. This problem is highly artificial, but it is designed to show the disadvantages of the normal theory.

The corresponding mass haul curve is shown in Fig. 3 (*b*). Assume a free haul limit of 1000ft. Now according to the theory given above five units of excavation lie within the free-haul limit and five units are overhauled, the overhaul amounting to twenty-five station units.

The programme of haul implied in the foregoing method is as follows:

Excavation between 0 and 100ft is deposited between 1900ft and 2000ft.; excavation between 100ft and 200ft is deposited between 1800ft and 1900ft . . . . excavation between 900ft and 1000ft is deposited between 1000ft and 1100ft.

But suppose that the following programme is adopted:

Excavation between 0 and 100ft is deposited between 1000ft and 1100ft.; excavation between 100ft and 200ft is deposited between 1100ft and 1200ft. . . . . excavation between 900ft and 1000ft is deposited between 1900ft and 2000ft.

It is apparent that all the material is hauled 1000ft exactly and there is no overhaul. The amount of overhaul depends then not only on the length of free haul but also upon the programme of haul adopted on the site. It should be noted particularly that the total mass haul is a constant quantity, independent of the haul programme, being the product of the volume excavated and the distance between the centres of gravity of the excavation and filling.

It may be argued that since the total mass haul is constant, irrespective of the haul programme, then the extra costs for overhaul balance with the lower costs in the free haul region to give a price which is equivalent to hauling all material 1000ft. This is probably true for the example as quoted, but if the free haul limit is altered then the relationship between the quantities is no

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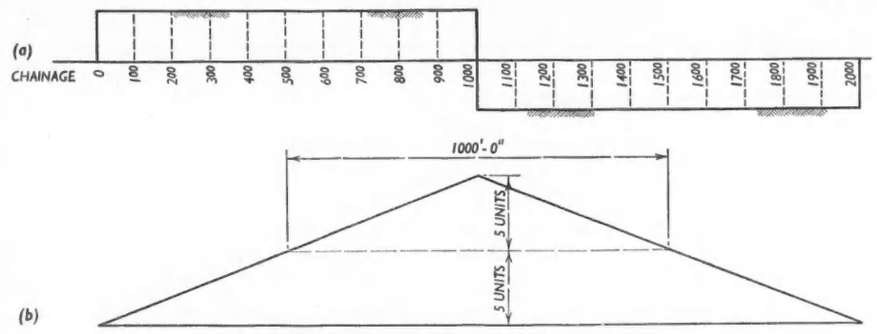

Fig. 3—Simple mass haul curve, limit of free haul 1000ft

longer quite so simple. No doubt by adjusting the various prices a balance could again be reached, but it means introducing special calculations to mitigate the effects of introducing an artificial concept.

Further the plant used for excavating and hauling will have a profound influence upon the haul programme, for example a tractor and scraper will pick up spoil from a shallow cut extending over an appreciable longitudinal distance, while a face shovel feeding dumpers will be taking material from a particular spot. In the face of various excavation methods any attempts to define limits of overhaul become very complex.

Thus it is apparent that the safest criterion is the total mass haul.

Total Mass Haul

A longitudinal section consisting of one length of excavation and one length of fill is shown in Fig. 4 (*a*). The section is balanced, the excavation and fill being equal. A diagram such as that in Fig. 4 (*b*) is prepared, in which ordinates are erected to some scale to represent the volume of excavation or fill over particular lengths of the section. Thus the ordinate 2 represents the volume of excavation between 150ft and 250ft. In most cases then the ordinate 2 will be equal to the cross-sectional area at 200ft multiplied by 100. Now in a polar diagram as shown in Fig. 4 (*c*) the ordinates from Fig. 4 (*b*) are plotted in one line with due regard to sign, *a*—*b* representing the ordinate 1 from Fig. 4 (*b*) and *b*—*c* representing the ordinate 2. The excavation ordinates are plotted downwards and fill ordinates are plotted upwards. Since the excavation and fill balance then the ordinates plotted in Fig. 4 (*c*) must finish at the starting point *a*.

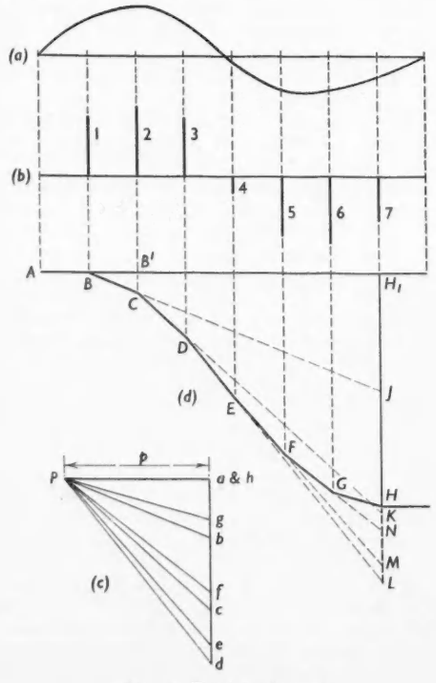

Fig. 4—Total haul curve

Choose a pole *P* at any distance *p* to the left of but level with *a*. Join *P* to the points *a*, *b*, *c*, &c. Now the Fig. 4 (*d*) is prepared by projecting the lines of the ordinates 1, 2, 3, &c. in Fig. 4 (*a*) vertically downwards. In Fig. 4 (*d*) draw the lines *AB*, *BC*, &c. parallel to the lines *Pa*, *Pb*, *Pc*, &c. in Fig. 4 (*c*). The final ordinate H_1—*H* represents the total mass haul in the section considered.

Proof.—In Fig. 4 (*d*) continue the line *B*—*C* to meet H_1H at *J*, similarly continue *CD*, &c. to points *K*, *L*, *M* &c. In triangles BJH_1 of Fig. 4 (*d*) and *Pba* of Fig. 4 (*c*)

$$\angle BJH_1 = \angle Pba$$
$$\angle JBH_1 = \angle bPa$$
and $$\angle JH_1B = \angle baP = 90 \text{ deg.}$$

Therefore, the triangles are similar.

Hence
$$ab/p = JH_1/BH_1$$

Therefore
$$JH_1 = ab \times H_1B/p$$

Similarly
$$JK = bc \times H_1B^1/p.$$

And similar expressions may be found for *KL*, *LM*, &c.

But

H_1H = The algebraic sum of H_1J, *JK*, *KL*, &c.
= Σ volume × horizontal distance from H_1/p
= 1st moment of volumes about H_1/p.
= Total volume haul/*p*.

Properties of the Diagram

A more complicated case is shown in Fig. 5. The following properties should be noted. (*a*) The excavation and fill balances between the points *A* and *C*, *C* and *E*, *E* and *G*., i.e. between successive maximum and minimum points on the total mass haul diagram. (*b*) The total mass haul between these points is equal to the vertical distance between these maximum and minimum points. If these distances are summed the total mass haul over the whole section is obtained. (*c*) Earth is moved from excavation to fill down the slope of the total mass haul curve. Thus excavation from *AB* moves to fill at *BC* and from *DE* to *CD*, in each case the horizontal direction of movement being the same as that obtaining when sliding down the total mass haul curve. This property depends upon the fact that the pole is placed to the left of the polar diagram for a section in which the excavation is considered as a downward quantity and fill is considered as an upward quantity.

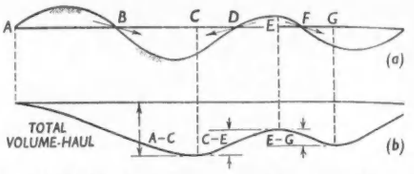

Fig. 5—Total haul curve, showing direction of movement

Conclusion

The determination of overhaul from a normal mass haul curve depends not only upon that curve but upon the manner in which the excavation, hauling and filling was carried out. If prices are used based upon such a use of the mass haul curve for previous work then probably the final result will be somewhere near the truth. However, there is the possibility of making serious errors, and it would probably be better to adopt a method depending upon the total mass haul.

British Coal Utilisation Research Association

The annual report of the British Coal Utilisation Research Association for 1959, which has just been published, shows that increased emphasis has been placed on those aspects of the association's work directed towards improving the coal industry's competitive position in fuel utilisation under present conditions. These objectives include making as nearly automatic in operation as possible industrial boilers and boilers for central heating buildings such as blocks of flats ; improving fuel handling and ash disposal ; and minimising atmospheric pollution.

Investigations were initiated during the year into the mechanical handling of small coal, and tests were carried out with a model bunker and an experimental bucket elevator. It was confirmed that the presence of very fine particles and the high moisture contents to which their presence leads were chiefly responsible for impeding flow and that their removal made a considerable improvement.

Studies of heat transfer to the furnace tube of shell boilers were continued on a model furnace tube plant and the results compared with measurements made on the Economic boiler at Leatherhead. This boiler has also been used for investigations into the effects, on load-efficiency characteristics, of changing the length of the stoker and of controlling undergrate air distribution by fixed vertical baffles. In a study of grit emission it was found that avoiding overloading and keeping excess air to the minimum were of importance in minimising emission.

A small automatic chain-grate stoker being developed for central heating in buildings such as large blocks of flats underwent extensive testing at Leatherhead. The modified automatic control system of this stoker now enables coals of differing characteristics to be used, and satisfactory burning at a rate as low as one-twentieth of full load to be achieved when required. The report states that combustion efficiencies of over 75 per cent were attained over the whole range of burning rates with negligible emission of smoke, dust or grit. A simple addition to the stoker speed regulator enables the controlled water temperature to be varied according to the outside air temperature, and a method of withdrawing fuel automatically from bunkers has been developed. A field trial installation of the stoker in a London block of flats has operated satisfactorily and the National Coal Board is arranging for the commercial development of this stoker.

Other fields of work described in the report include : Research on deposits and corrosion in water-tube boilers, which is carried out for the Boiler Availability Committee ; Research on the gasification of low-grade coal, under contract with the Ministry of Power ; and study of the structure and reactivity of graphite used in moderators for nuclear reactors, under an arrangement with the U.K. Atomic Energy Authority.

THE ENGINEER

Technical Contributors Section

AUGUST 1960

An Indirect Method of Measuring Static Temperature in Supersaturated Expanding Steam

By DENIS J. RYLEY*

This article describes a means whereby the local static temperature in an undercooled expansion can be measured by an indirect method. The method consists of establishing a sequence of recovery factors for a known nozzle profile for wholly superheated flow by using an axial thermocouple to determine the distribution of adiabatic wall temperature. The recovery factors so found in the calibrating test are then employed to determine the static temperature for the undercooled expansion in conjunction with the new distribution of adiabatic wall temperature. This procedure is valid only if there is a closely similar axial distribution of Reynolds number, Mach number, and Prandtl number for both tests. Experiments using live steam at 30 lb per square inch gauge show that within certain temperature limits the undercooled static temperature can be inferred with fair accuracy, but the method is unsatisfactory for very small and very large degrees of undercooling.

IT is well known that any thermometric device situated at rest within a high-speed gas flow will indicate a temperature differing from the so-called static temperature, the latter being the value obtained in the absence of relative motion between thermometer and gas. The value of temperature indicated will be some value intermediate between the true static temperature and the reservoir temperature depending upon the degree of temperature recovery attained by the gas when brought to rest at the measuring device. It is usual to define the recovery factor, σ, in the following way :

$$\sigma = \frac{T_{aw} - T_s}{T_o - T_s} \quad . \quad . \quad . \quad (1)$$

where T_{aw} is the adiabatic wall temperature, i.e. the recovered temperature assumed to be uninfluenced by heat losses, T_o is the reservoir temperature and T_s is the static or stream temperature.

For economy in space and convenience in mounting, the thermocouple junction has considerable advantages over other temperature sensitive devices and a great deal of experimental work has been done in this connection using thermojunctions. The flowing fluid has generally been air and the work has been done in the context of aeronautical research, but the need to measure the temperature on the boundary of a fluid extends widely in engineering in general, not least in steam engineering.

Temperature measurements within expanding steam have been attempted by Batho,[1] Muller,[2] Stewart,[3] Nusselt,[4] and recently by Kerr, Scott and Sorour,[5] but a number of problems remain unsolved, and some unexpected phenomena, particularly connected with the failure of steam to condense at saturation conditions, are still unexplained. In order to provide data on recovery factors with steam, experimental work was initiated by Mr. H. Barrow and the writer,[6] and published as an article in a former issue of this journal. Thus steam was expanded in the nozzle *B* (Fig. 1) and adiabatic wall temperatures were measured using a specially designed thermocouple probe fully described in the article.[6] To avoid any complications associated with possible undercooling of the steam, the initial live steam conditions were so chosen that at the end point of the expansion the steam had a few residual degrees of superheat. By measuring T_{aw} and T_o in equation (1) and calculating T_s from the known profile of the nozzle, the variation of σ during the latter part of the expansion was obtained and compared with the theoretical value calculated from the Prandtl number. This work led directly to the further work to be described in this article.

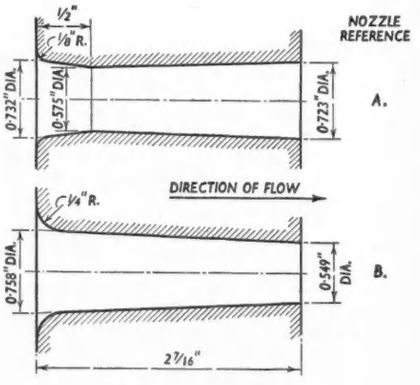

Fig. 1—Nozzle reference

The Recovery Factor

It may be shown by dimensional analysis that the recovery factor may be expected to be a function of the non-dimensional groups defining respectively the Reynolds number, the Mach number and the Prandtl number, i.e.

$$\sigma = f(Re, M, Pr) \quad . \quad . \quad . \quad (2)$$

The nature of the function and the relative contributions of each group is not known, but it is believed that the Prandtl number is the most influential. The work to be described does not necessitate finding either the function or the respective powers to be assigned to the non-dimensional groups, but is based on the supposition that σ can be completely or very nearly described in terms of these three groups.

Symbols

- σ—Recovery factor.
- T—Temperature.
- Re—Reynolds number
- M—Mach number.
- Pr—Prandtl number.
- μ—Absolute viscosity.
- p—Pressure.
- $v = \frac{1}{\rho}$—Specific volume.
- ρ—Density.
- γ—Isentropic index.
- k—Thermal conductivity.
- a—Local acoustic velocity.
- V—Velocity.
- C_p—Specific heat at constant pressure.
- x—Distance from nozzle inlet.

Subscripts

- o—Reservoir.
- s—Static.
- aw—Adiabatic wall.
- 1—Calibration.
- 2—Test.

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The Measurement of Undercooled Steam Temperatures

Using a given nozzle and temperature probe there will be, for the expansion of live steam of given initial conditions, a certain unique axial distribution of recovery factor values capable of being calculated from equation (1). For this purpose, T_{aw} must be observed experimentally and T_s calculated from the known nozzle profile. If a different set of initial conditions are employed, but it can be shown that the axial distribution of *Re*, *M* and *Pr* are the same, or substantially the same, as previously, it is a reasonable inference that the previous axial distribution of recovery factor values will apply for the new case. In such an event, for the second case, it is only necessary to know T_o and obtain T_{aw} experimentally and equation (1) may be utilised to define the value of T_s that must prevail at any section. This provides an indirect way of finding the axial variation of T_s. For comparative expansions within the superheat zone such a procedure would have a limited value. If, however, comparison is being made between two expansions, one known to be entirely dry, and the other proceeding from a condition of low initial superheat and thought to be supersaturated, it is possible to infer the distribution of static temperature for the second case and to compare this with the distribution which would, in fact, occur for a supersaturated expansion. For such a comparison to be made it is necessary for two main conditions to be secured. In the first place the respective distributions of *Re*, *M* and *Pr* must be closely similar for the two cases, as already indicated, and in the second place T_{aw} must not be subject to any special effects peculiar to a metastable as distinct from a wholly stable expansion. If the steam is subject to slow heterogeneous nucleation it would seem that both conditions should be fulfilled at least while the supersaturation ratio remains high, but there are indications that this may not be the case. Where rapid self-nucleation occurs the method becomes invalid.

Experimental Work

Experimental work is facilitated if the expansion takes place relatively slowly and tests were conducted in the first instance on nozzle *B* (Fig. 1) which provides a radiused inlet and a long conical convergence to the exit. For the tests to determine σ, the inlet pressure was maintained at 30 lb per square inch gauge and 382 deg. Fah. of superheat employed. The back pressure was subcritical and the exit pressure is effectively that of a throat, namely $0{\cdot}545 \times 44{\cdot}7 = 24{\cdot}6$ lb per square inch absolute, and the state point locus for isentropic expansion is shown on Fig. 2 as *CD*. It will be observed that the entire expansion is within the superheat region and no question of phase change arises. A temperature search gives the experimental curve for adiabatic wall temperature, T_{aw_1}. Calculations based on insentropic flow between the known terminal conditions within the known profile enable the theoretical variation of static temperature T_{s_1} to be drawn as shown (Fig. 3). Whereas the expansion is not, in fact, isentropic, the efficiency is very high and if allowances were made for the losses, calculations show that the curve T_{s_1} would not be materially displaced. The distribution of recovery factor, σ, may now be calculated from equation (1), and is shown at the bottom of Fig. 3. The accuracy with which this may be deduced from the readings of T_{aw_1} and the reservoir temperature, T_{o_1}, has been discussed in the paper, Reference 6, but it may be stated here that the accuracy improves as the exit is approached.

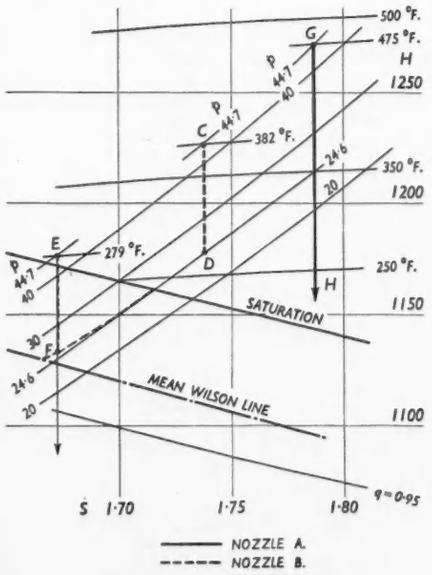
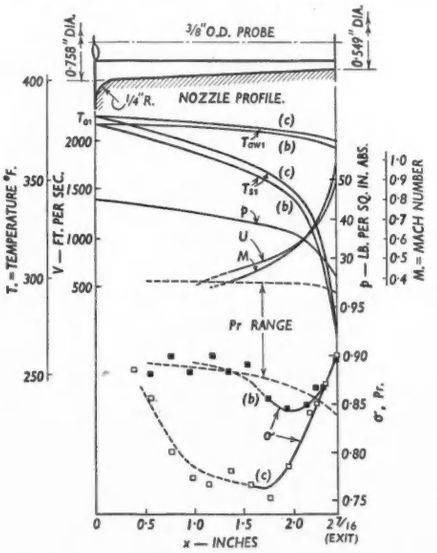


Fig. 2—State point loci



Reproduced from Barrow and Ryley, THE ENGINEER. The curves (*c*) are applicable for the present work.

Fig. 3—Axial distribution of flow variables and recovery factor

The distribution of σ so found may now be employed for the expansion *EF* (Fig. 2). The supply pressure was 30 lb per square inch gauge as previously, though this is not essential, but the initial temperature was so chosen that saturation conditions are achieved early in the expansion. In the event of the steam supersaturating completely the exit condition will be at *F* on an extended superheat pressure parameter of 24·6 lb per square inch absolute, provided the previous isentropic expansion index, taken as 1·3, still holds.

Fig. 4 shows a comparison of the respective distributions of *M*, *Pr* and *Re* for the two expansions *CD* and *EF*. For $Re = V_{x\rho}/\mu$, *V* was calculated from the nozzle profile ; *x* was the distance from inlet to the section considered and $\rho = 1/v$ was calculated from the properties of steam. The viscosity was calculated from the expression given by Sigwart.[7]

$$\mu = [0{\cdot}143T + 56] \times 10^{-7} \text{ lb/ft.sec.} \quad . \quad (3)$$

where *T* is in degrees Fahrenheit. For

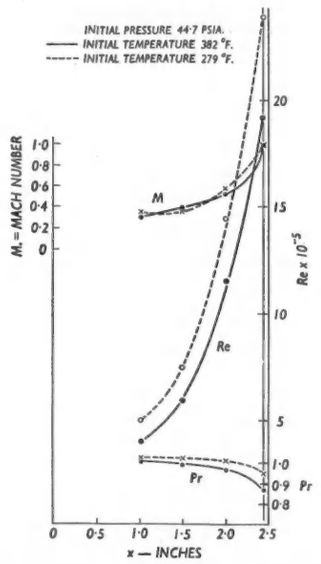


Fig. 4—Variation of Mach No., Reynolds No. and Prandtl No. through nozzle *B*

$M = V/a$, the local acoustic velocity *a* was taken as $\sqrt{p\nu\gamma g}$ where $\gamma = 1{\cdot}3$. For $Pr = \mu C_p/k$, *Cv*, which is sensibly constant for the whole range of experiment was taken as 0·49 from Timrot.[8] The thermal conductivity *k* was taken from the results due to Keyes and Sandell.[9] For the supersaturated steam it was assured that equation (3) remained valid for μ and that the Keyes and Sandell curves for *k* could be extrapolated for a short distance beyond the saturation boundary. The range of properties for each expansion was calculated for four positions which gave adequate definition of the trends of *Re*, *M* and *Pr* for purposes of comparison.

A study of Fig. 4 reveals that close agreement exists between the *M* curves, and passable agreement between the *Re* and *Pr* curves respectively. Fig. 5 shows the

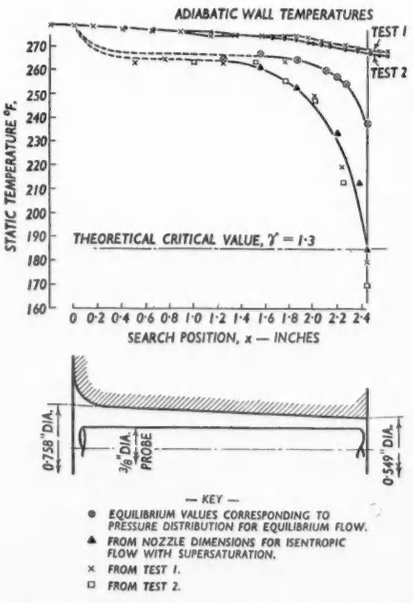


Fig. 5—Static temperature variation for nozzle *B*

inferred values of static temperature, T_{s_2}, calculated from

$$T_{s2} = \frac{T_{aw2} - \sigma T_{o2}}{1 - \sigma} \quad . \quad . \quad . \quad (4)$$

Two runs were taken for T_{aw_2} and both

used for calculating T_{s_2}. A number of points have also been calculated from the nozzle dimensions, assuming (*a*) completely supersaturated flow, and (*b*) equilibrium flow. It is very evident that the values of T_{s_2} support the former and suggest that the expansion is completely supersaturated.

With the nozzle *B*, the expansion discontinues at the critical pressure and the maximum degree of undercooling is about 54 deg. Fah. For an expansion continued further, undercooling to the extent of about 60 deg.–70 deg. Fah. may be expected for these conditions before nucleation supervenes, the exact value depending upon the position of the Wilson line, which position is only approximately known. The position shown as a guide on Fig. 2 is the mean of the results of many workers.

An attempt was made to extend the above method of measurement to the greater degrees of undercooling associated with supersonic flow and further tests of the same nature were conducted with nozzle *A*. Fig. 6 shows the nozzle *A* profile, the calculated distribution of T_{s_1}, and the experimental values of adiabatic wall temperature, T_{aw_1}, for two runs giving the state point locus *GH* on Fig. 2. Also shown are the values of recovery factor σ as calculated from these runs. It will be seen that the rise in σ as the critical pressure is approached, observed previously, is here confirmed and there is reasonable agreement between the two curves for the subsequent expansion. Several tests were then undertaken for initial steam conditions at *E* and the best of these selected for analysis. The measured distribution of T_{aw_2} for such an expansion will enable an inferred trend of values for T_{s_2} to be calculated as before from equation (4). The results so obtained are shown on Fig. 7 together with a number of calculated points representing selected temperatures for fully supersaturated and for equilibrium expansions respectively. It is again evident that the steam is supersaturating and a reasonable prediction of static temperature, T_{s_2}, can be made up to and just beyond the throat, but the inferred values of T_{s_2} thereafter are seriously in error.

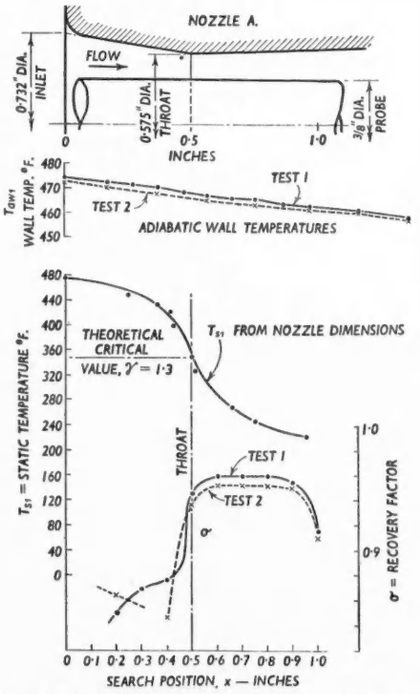


Fig. 6—Variation of recovery factor for nozzle *A*

Magnitude of Errors

The extent of the undercooling at any section within the nozzle is a measure of uncompleted reversion. A temperature in excess of that appropriate to fully supersaturated expansion indicates that some reversion has taken place. In fast expansions the extent of the reversion is known to be small, and it may be expected that the undercooling will be almost the full amount until the supervention of nucleation. Nevertheless, an inferred temperature in excess of the minimum value for a section might indicate reversion, or equally it might indicate the accumulated errors of measurement. It is necessary, therefore, to examine the extent to which the inferred temperature, T_{s_2}, might be in error as the result of fluctuations in reservoir temperature.

Considering equation (1) it is clear that the magnitude of the error in σ cannot be assessed by considering the independent effects of error in T_{aw}, T_s and T_o and summing, since these quantities are not independent. Any change in T_o for either calibration or test will promote changes concurrently in T_{aw} and T_s. Provided, however, the change in T_{o_1} is small, an assessment can be made of its effect on T_{aw_1} and T_{s_1} and hence on σ. Similarly, a small change in T_{o_2} produces a predictable change in T_{aw_2}.

Considering the effects of variation in T_{o_1}, it will be seen from Fig. 6 that for a variation of ± 1 deg. Fah., the corresponding variation in T_{aw_1} is about $\pm 1{\cdot}5$ deg. Fah. at the middle of the expansion. The concurrent variation in T_{s_1} will depend upon the position within the expansion and may be assessed thus :

$$T_{s1}=T_{o1}\left(\frac{p}{p_o}\right)^{\frac{\gamma-1}{\gamma}} \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Taking $\gamma=1{\cdot}3$,

$$T_{s1}=T_{o1}\left(\frac{p}{p_o}\right)^{0\cdot 231}$$

$$\delta T_{s1}=\frac{\partial T_{s1}}{\partial T_{o1}}\,\delta T_{o1}=\left(\frac{p}{p_o}\right)^{0\cdot 231}\delta T_{o1} \quad . \quad . \quad (6)$$

From equation (1), and using the notation applicable to the calibration,

$$\delta\sigma=\frac{\partial\sigma}{\partial T_{aw1}}.\,\delta T_{aw1}+\frac{\partial\sigma}{\partial T_{s1}}.\,\delta T_{s1}+\frac{\partial\sigma}{\partial T_{o1}}.\,\delta T_{o1}$$

$$=\frac{\delta Taw_1}{T_{o1}-T_{s1}}+\frac{(T_{aw1}-T_{o1})\;\delta T_{s1}}{(T_{o1}-T_{s1})^2}+\frac{(T_{s1}-T_{aw1})\delta T_{o1}}{(T_{o1}-T_{s1})^2} \quad . \quad . \quad . \quad (7)$$

It was found possible to maintain T_{o_1} to within $\pm 0{\cdot}5$ deg. Fah. of the nominal value. The approximate concurrent variation, δT_{aw_1}, is $\pm 0{\cdot}75$ deg. Fah., and δT_{s_1} for, say, the controlling section is $\pm(0{\cdot}545)^{0\cdot 231}\times 0{\cdot}5=\pm 0{\cdot}43$ deg. Fah. Evaluating $\delta\sigma$ for, say, the nozzle *A* using these values, it is found to be $\pm 0{\cdot}002$ for this section, a value comparable with that shown on Fig. 6.

Proceeding to the test itself, which utilises the value of σ thus investigated, the influence of the error $\delta\sigma$ on equation (4) may now be considered. The variation of T_{o_2} will be within $\pm 0{\cdot}5$ deg. Fah. as before, and that corresponding for T_{aw_2} will be $\pm 0{\cdot}75$ deg. Fah., as before. These are mutually dependent, but independent of $\delta\sigma$.

From equation (4),

$$\delta T_{s2}=\frac{\partial T_{s2}}{\partial\sigma}.\,\delta\sigma+\frac{\partial T_{s2}}{\partial T_{aw2}}.\,\delta T_{aw2}+\frac{\partial T_{s2}}{\partial T_{o2}}.\,\delta T_{o2}$$

$$=\frac{(T_{aw2}-T_{o2})\delta\sigma}{(1-\sigma)^2}+\frac{\delta T_{aw2}}{(1-\sigma)}-\frac{\sigma\,.\,\delta T_{o2}}{(1-\sigma)} \quad . \quad . \quad (8)$$

Evaluating δT_{s_2} for the errors given and for $\delta\sigma=\pm 0{\cdot}002$, the error in the inferred value of T_{s_2} for the controlling section of nozzle *A* is found to be $\pm 1{\cdot}8$ deg. Fah. from the value of T_{s_2} obtaining with no error in T_{o_2}.

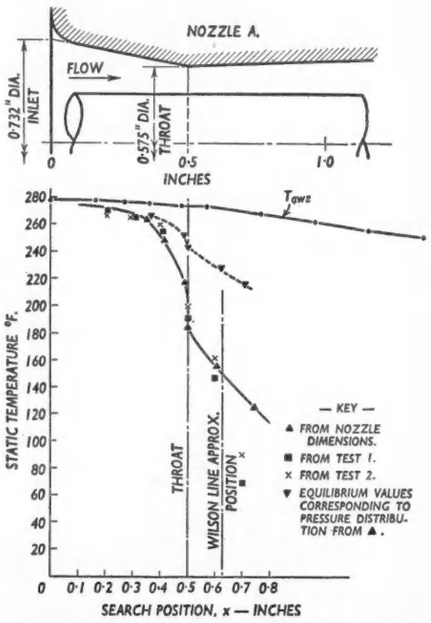


Fig. 7—Static temperature variation for nozzle *A*

The analysis is also valid for nozzle *B*. Since the convergence angle is much smaller with this nozzle than with nozzle *A*, the sub-critical expansion is spread over a greater length and experimentally determined values of T_{aw} are likely to be more accurate. Likewise, the distribution of T_{s_1} can be calculated with greater accuracy.

The foregoing analysis is based only on the stability of the reservoir temperature and does not embrace errors in the reading of instruments, or in the instruments themselves, or in the initial calibration of the thermocouple. The latter is fully described in Reference 5. It also assumes equality of σ for calibration and for test.

Discussion

An examination of the results obtained experimentally and a consideration of the probable magnitude of δT_{s_2} indicates that a very fair estimate may be made of static temperature for up to about 60 deg. Fah. of undercooling and confirmation thus obtained for the existence of suspected supersaturation. The above was undertaken using test nozzles, but the method is applicable wherever a temperature probe with pre-determined recovery factors can be inserted, and is, of course, not confined in application to the case where undercooling is present. Its special value in the latter case lies in the fact that it provides means of finding another function of state besides the pressure, a difficult task with any flowing fluid, but particularly so with one liable to sudden change of phase upon slight provocation.

It was pointed out earlier that T_{aw} must not be subject to any special effects peculiar to a metastable expansion. It would be expected, at least in principle, that provided no phase change occurred, the reservoir temperature would be approximately recovered at any point in the expansion, whether or not the steam had at some point been undercooled. Evidence exists, however, from other workers that this is not necessarily so. Batho,[1] Muller[2] and more recently, Kerr, Scott and Sorour[5], all using axial thermocouples, have recorded temperatures below the saturation value, and Kerr, Scott and Sorour, by promoting a plane shock in the divergent portion of their nozzle have shown

that reversion to wet-saturated conditions can be thus enforced. They were unable to provide a final explanation to account for this effect, but they found that if great care was taken to eliminate minute water droplets the adiabatic wall temperatures corresponded to those for the expansion of a dry gas. The present writer spent considerable time searching for any evidence of this type of temperature depression and found none. No special attempt was made to eliminate water droplets by the provision of any inertia separating devices, but the layout of the plant was such that the survival of any droplets was unlikely. Thus the steam to the apparatus was supplied through a large gas superheater very lightly loaded and the superheat was slowly reduced until the point *E* (Fig. 2) was attained by the reservoir steam. A small degree of throttling took place at the valve prior to the live steam reservoir. It is thought that the considerable thermal storage capacity in the superheater, and the fact of its excess temperature over that of the supply steam, together with the late throttling, effectively eliminated any small water drops.

It will be observed that the T_{aw_2} curve on Fig. 7 shows no discontinuity beyond $x=0{\cdot}5$in that can clearly be associated with reversion although it is certain that nucleation is taking place. It was found, however, that well beyond the condensation point the galvanometer became unstable, and still later in the expansion, where the search tube was presumably covered by a liquid film, reasonably stable values of temperature could be obtained and that these corresponded to the calculated local value for saturated conditions.

Reverting to Fig. 4 it will be observed that the disparity between the respective Prandtl numbers in nozzle *B* for the calibration and the test becomes greater towards the nozzle exit, and it might be supposed that a progressive error would occur in the predicted test temperatures as the expansion proceeds. This is certainly the case, but as the recovery factor for a dry gas is known to be approximately $(Pr)^{1/3}$ for turbulent flow the effect is diminished, particularly as *Pr* for steam is approximately unity. There is, indeed, no reason in principle why the calibrating test should not be so chosen as regards initial conditions that the best agreement possible is promoted between the respective pairs of non-dimensional groups at the point in the expansion where the highest accuracy in inferred temperature is sought.

There is clearly scope for considerable refinement in this method of testing. For example, thermocouples have a very rapid response, and by locating one in the live steam reservoir and another at the test section and reading two galvanometers simultaneously, the errors explored above due to temperature fluctuations during a test could be avoided, and improved accuracy promoted.

Acknowledgments

The above investigation was conducted in the Department of Mechanical Engineering, University of Liverpool. The writer is indebted to his colleague, Mr. H. Barrow, for helpful discussions.

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Thermal Fatigue Investigations

By M. COX, B.Sc., A.M.I.Mech.E., and E. GLENNY, B.Sc., F.I.M.

Components which are subjected in service to many abrupt changes in temperature may fail as a result of fatigue induced by cyclic thermal stresses; such conditions occur in the blading of gas turbine engines during starting and shut-down. A description is given of research work in progress at the National Gas Turbine Establishment in which laboratory techniques have been used to investigate temperature transients in turbine blades and to subject materials to simulated service conditions using beds of fluidised solids for heating and cooling test specimens. Results of this work which are given indicate the major factors involved, and their relative importance in governing the thermal fatigue behaviour of creep resistant alloys.

THE problem of steady thermal stresses is a familiar one in any engineering application where different regions of a component or structure operate at different temperatures. The problem of transient thermal stresses occurs where the service conditions involve rapid heating or rapid cooling, e.g. in exhaust valves, gun barrels, die casting, nuclear reactors, and in the blading of aircraft gas turbines. In the latter, transient stresses are produced as a result of the thermal shocks produced by rapid heating during starting or acceleration, and by rapid cooling during deceleration or on shut-down. The repetition of such thermal shocks can eventually cause failure by thermal fatigue cracking.

Origin of Thermal Fatigue

When the temperature across the section of a solid body is changed suddenly and non-uniformly, e.g. by exposure to a medium of appreciably different temperature, thermal gradients will be set up. Their magnitude depends on the rate of heat input or heat extraction at the surface, and on the thermal conductivity of the material. The higher the heat transfer rate at the surface and the lower the thermal conductivity, the greater will be the thermal gradients.

The development of strains and associated stresses from transient temperature gradients can be followed by considering the rapid heating and rapid cooling respectively in high velocity gases of a turbine blade with a typical cross-section as shown in Fig. 1. The heat transfer coefficient at the leading edge is nearly three times the mean value around the profile, and heating or cooling will therefore be most intense at this region. Both the leading and trailing edges of the blade are relatively thin and so if the gas temperature is suddenly changed, the temperature at these edges, particularly at the leading edge, will alter much more rapidly than at the comparatively massive centre section A considerable difference builds up between the edge (T_e) and the average temperature (T_m) of the blade (Fig. 2). This difference reaches a maximum quite quickly, and then decays slowly

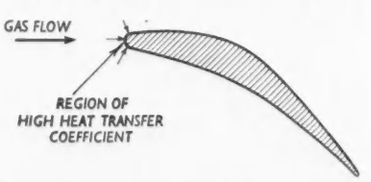


Fig. 1—Cross section of typical turbine blade

as all parts of the blade approach a steady uniform temperature. At any instant the thermal strain is the product of the difference between T_e and T_m, and the coefficient of expansion of the material over the temperature range T_e to T_m. During rapid heating, the edges try to expand more quickly than the less rapidly heated interior, but their expansion

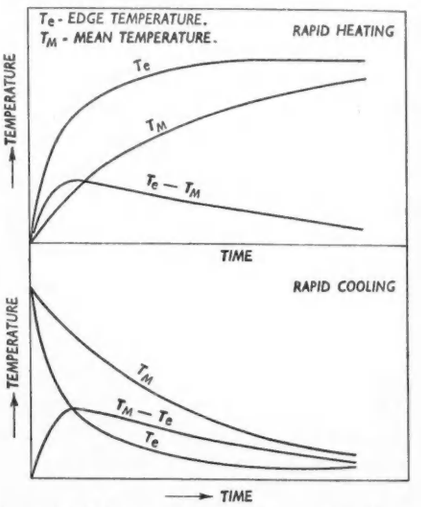


Fig. 2—Variation of T_e, T_m and T_e—T_m with time

is hindered by the greater mass of the interior and so compressive strains are developed in the edges. Conversely, on rapid cooling, the edges try to contract but are constrained by the interior, resulting in tensile strains. The manner in which the strain at the edge varies with time and with edge temperature during each thermal shock is shown in Fig. 3. The temperature at which the maximum strain occurs during rapid heating or rapid cooling is important, because the resistance of the material to the thermal strains may vary with temperature.

The temperature gradients incurred during starting or at shut-down of an aircraft gas turbine may be sufficiently large to produce plastic flow in compression or tension respectively. Repeated cycles of rapid heating or rapid cooling progressively reduce the

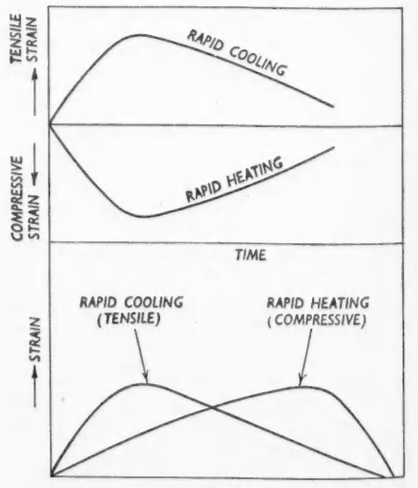


Fig. 3—Variation of surface strain with time and temperature

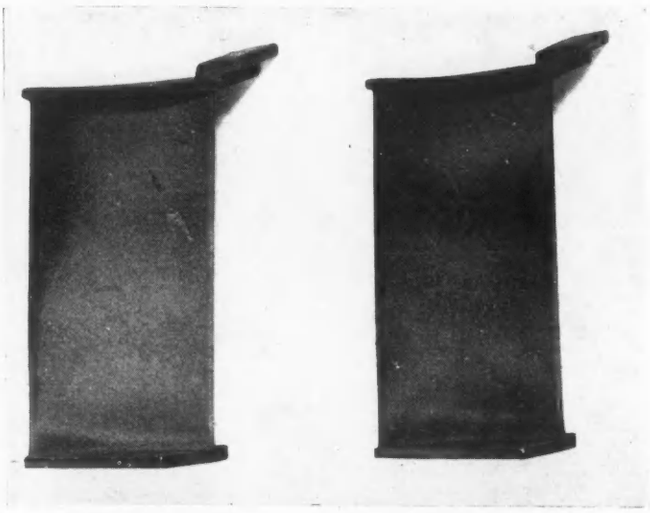


Fig. 4—Cracks in leading edge of nozzle guide vanes

capacity of the material for plastic deformation. Eventually thermal fatigue failure by cracking occurs in the manner exhibited by the nozzle guide vanes in Fig. 4.

Research Studies

The tendency of turbine blades to fail in this way will be governed by the blade design, the operating conditions and the properties of the material. The ability of a particular turbine blade design and material to resist thermal fatigue can be assessed from a series of engine tests in which the temperature changes encountered in service are repeatedly applied until failure occurs. The research work at the National Gas Turbine Establishment (N.G.T.E.), Pyestock, Hampshire, on this problem is more fundamental in outlook, and is directed towards a determination of the individual factors influencing thermal fatigue behaviour and to an understanding of the mechanism of failure.

Transient Temperature Distributions

It is obviously important to obtain information on the nature and magnitude of the transient strains and stresses, and therefore the temperature distributions must be determined. For simple shapes such as circular cylinders or flat plates, these can readily be derived by calculation, but for a relatively complex shape such as an aerofoil, calculations are more difficult. Nevertheless, transient temperature differences have been determined[1] from the relative rates of change of temperature in different regions of the blade, and from the relative magnitudes of surface heat transfer and of chordwise conduction near the edge, using exponential functions of time derived from accurate solutions of one-dimensional heat flow. Direct measurement of transient temperatures using thermocouples and high speed multi-channel recorders has been carried out. In the main, however, comparative data have been obtained with an electrical analogue designed[2] and manufactured at N.G.T.E.

In this equipment the flow of current under the action of applied voltage differences corresponds to the flow of heat in a plane sheet of blade material. The circuit has 600 nodal points at each of which the heat capacity and thermal conductivity of a square element of blade material are represented by a capacitor and four resistors connected to a five-pin socket. Shorting plugs, which have the effect of activating the nodal points, are inserted into the sockets so that the desired shape of blade may be mapped out on the analogue, as shown in Fig. 5. Heat transfer

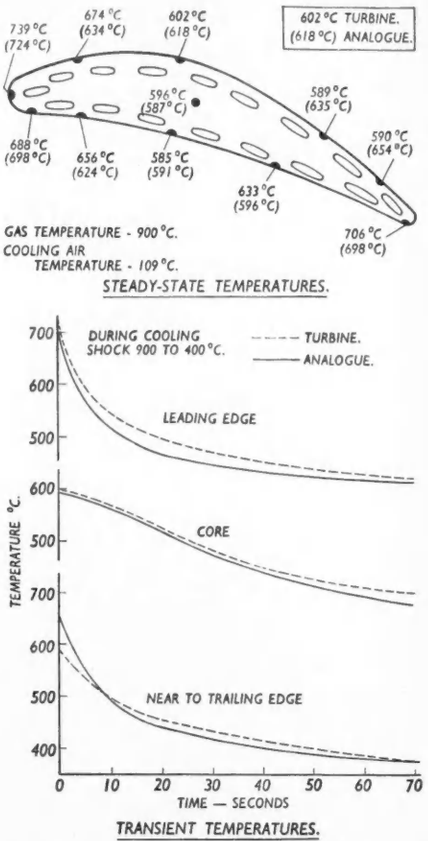


Fig. 6—Comparison between analogue and measured turbine blade temperatures

to the blade surfaces is represented by connecting points at the periphery of the blade through resistors to a bus-bar the voltage of which can be varied in accordance with the gas temperature to be simulated. The

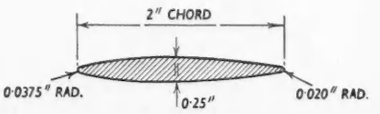


Fig. 7—Uncambered aerofoil section used in analogue measurements

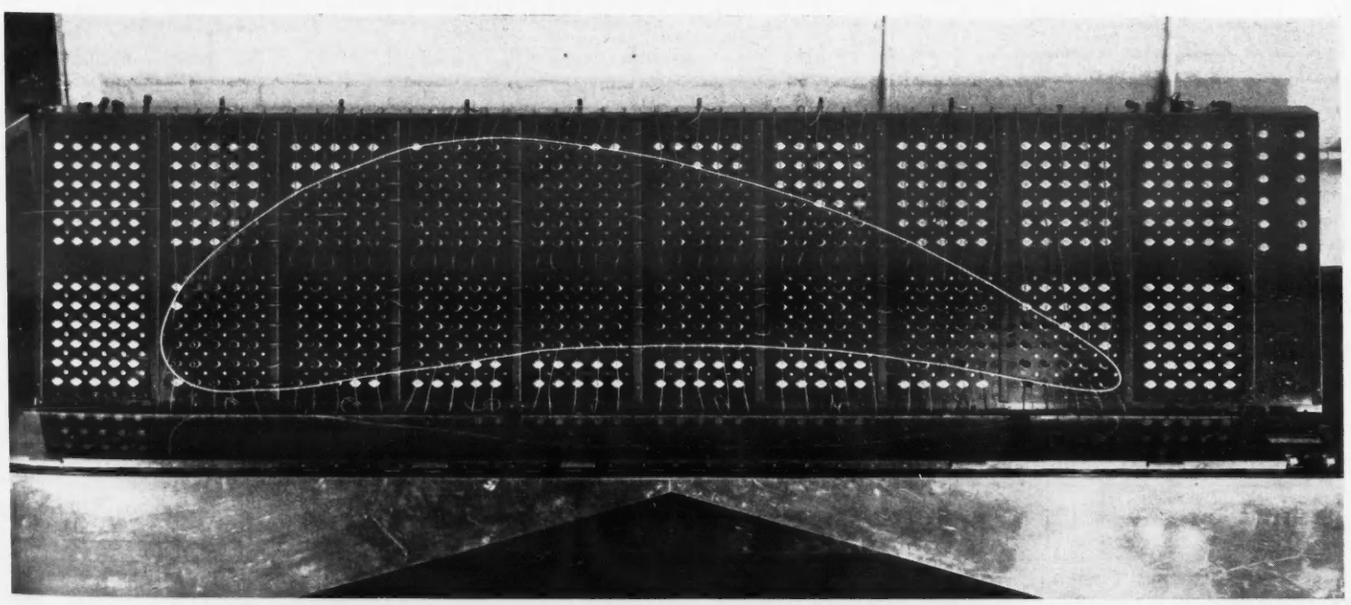
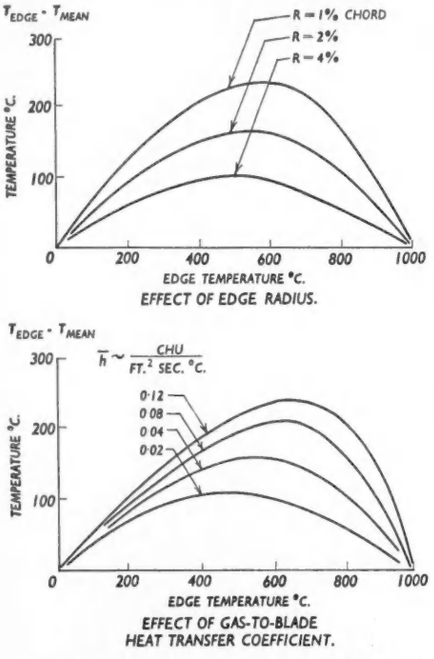


Fig. 5—Panel of electrical analogue for simulating transient temperature changes in turbine blades



A sudden change in gas temperature from 0 to 1000 deg. Cent. has been simulated.
$T_{edge} - T_{mean}$ is the temperature difference producing strain at the leading edge.

Fig. 8—Effect of edge radius and heat transfer coefficient on transient temperatures differences in uncambered aerofoil

resistors are variable and may be preset to simulate local variations in heat transfer coefficient. A step change in gas temperature is represented by a sudden change in voltage of the bus-bar ; the resultant changes in voltage at any point in the network may be monitored on a recording galvanometer. The voltage trace is converted to temperature-time by applying appropriate conversion

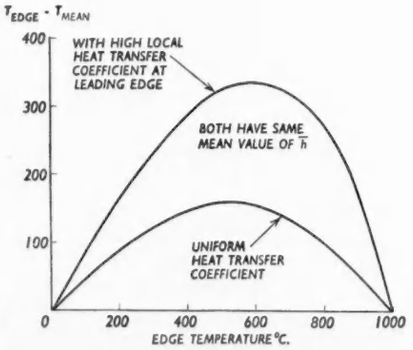

$T_{EDGE} - T_{MEAN}$
WITH HIGH LOCAL HEAT TRANSFER COEFFICIENT AT LEADING EDGE
BOTH HAVE SAME MEAN VALUE OF $\bar{h}$
UNIFORM HEAT TRANSFER COEFFICIENT
EDGE TEMPERATURE °C.

Fig. 9—Effect of high local heat transfer coefficient at leading edge of uncambered aerofoil

factors to both scales. The mean temperature at any instant may be obtained by isolating the network from the current source at the appropriate time and then measuring the voltage of the network when the total charge has spread uniformly among all the nodal points.

Although this simplified analogue suffers a number of limitations, notably that the material properties are represented as being invariant with temperature, quite good agreement has been obtained (see Fig. 6) between analogue estimates and measurements made with thermocouples in a gas turbine. Mainly, however, the analogue is used to obtain comparative data such as that shown for rapid heating in Figs. 7 to 9. Increase in the edge radius progressively reduces the value of $(T_e - T_m)$. The effect of a change in the level of heat transfer coefficient is seen to be that $(T_e - T_m)_{max}$ is approximately proportional to the square root of the $\bar{h}$ value. It is also evident that the temperature differences obtained with a variable distribution of heat transfer coefficient around the profile (similar to that in turbine blade operation) are appreciably greater than with a uniform distribution of the same mean value. From comparative tests of this sort, the effect of alterations in blade shape, cooling passage configuration and operating conditions on transient (or steady) temperature differences may be estimated.

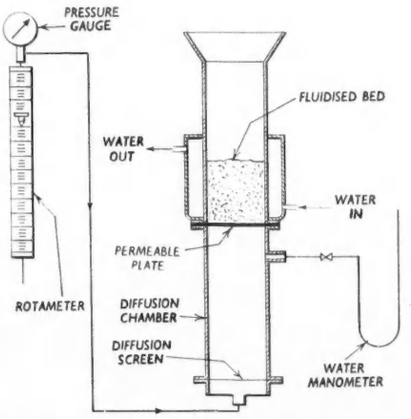


Fig. 11—Cold fluidised bed

Thermal Fatigue Behaviour

For a laboratory study of thermal fatigue behaviour it is desirable to use a test which provides well-defined reproducible conditions over a wide controlled range of temperature and heat transfer coefficient in different atmospheres, e.g. air or inert gas, and which can accommodate different shapes and sizes of test specimens. A review of possible methods indicated[3] that a bed of fluidised solids provided a very suitable medium for thermal fatigue tests. A relatively simple test specimen in the form of a symmetrically tapered disc (see Fig. 10) was designed so that the maximum thickness, diameter and peripheral radius were representative of the maximum thickness, chord and leading or trailing edge radius of a typical turbine blade. Rapid cooling was obtained by plunging the test specimen, slowly heated in an electric resistance furnace, into a cold air-fluidised bed of −150/+170 mesh zircon sand arranged as shown in Fig. 11 ; for rapid heating, the cold specimen was immersed in a similar fluidised bed heated by an electric resistance element immersed in the bed (see Fig. 12), and then slowly cooled in still air. Alternate rapid heating and rapid cooling was brought about by transferring the specimen between two fluidised beds maintained at different temperatures in the rig illustrated in Fig. 13. The heating times for each cycle were independently controlled and were normally sufficient to allow the interior as well as the surface layers of the specimen to attain the desired temperature. A full description of the equipment and

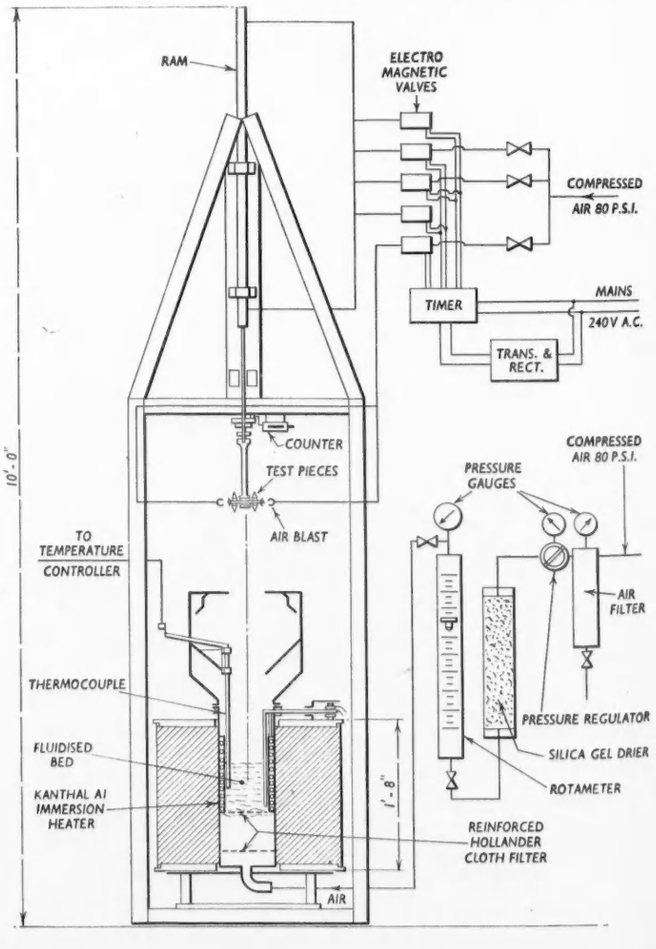


Fig. 12 (right)—Rapid heating thermal fatigue test

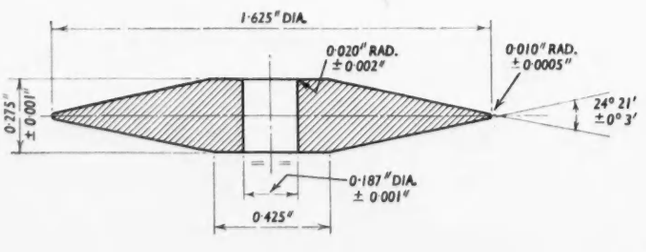


Fig. 10 (below)—Shape and dimensions of standard tapered disc

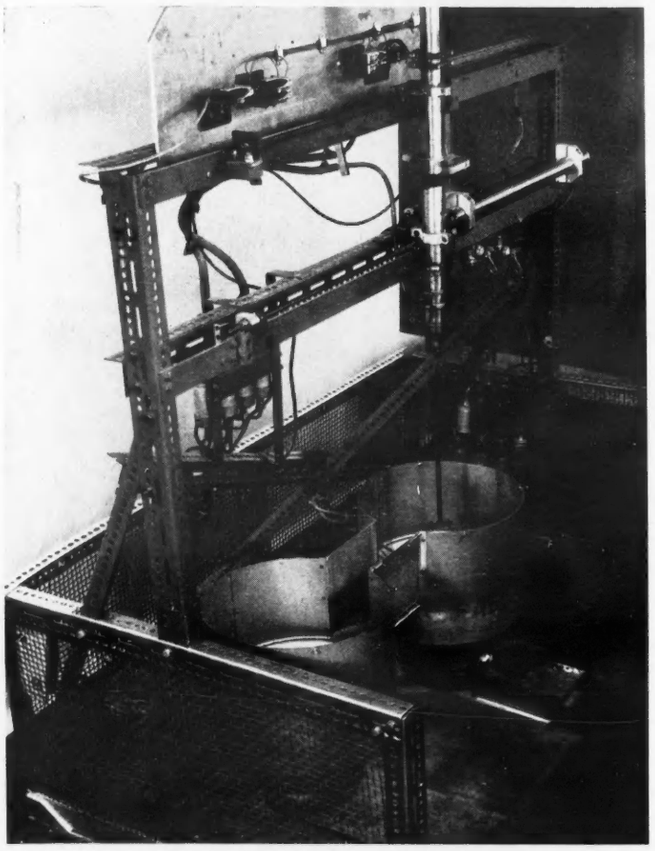


Fig. 13 (left)—Alternate heating and cooling rig

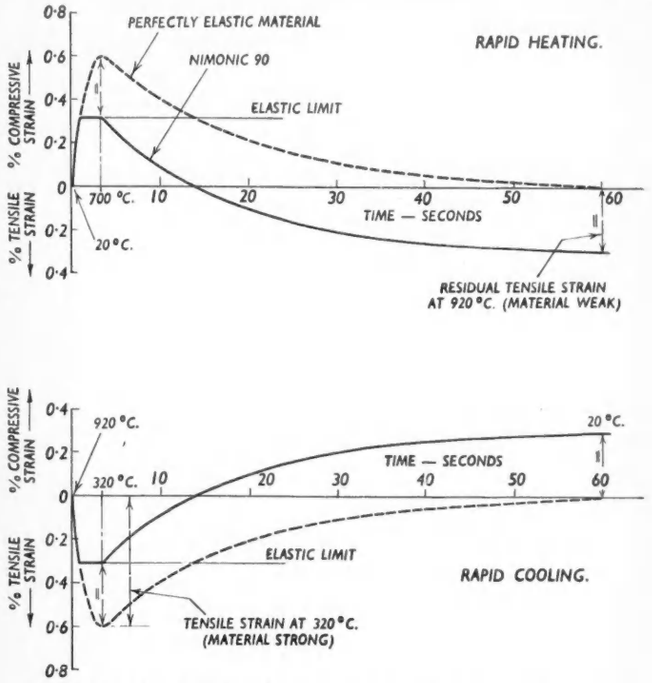


Fig. 15 (above)—Thermal strains in periphery of Nimonic 90 tapered disc

procedure is given in Reference 3. Each test specimen was examined at intervals of testing with a binocular microscope at ×30 or ×60 magnification. The criterion of failure was taken as the first appearance of a radial crack originating at the disc periphery. The thermal endurance, i.e. the number of cycles to failure was found to be remarkably consistent for a given material and test conditions, compared to the scatter usually found in vibration fatigue data.

Some of the results of tests[5] designed to evaluate the significance of the major variables are given in Figs. 14 to 18. Probably

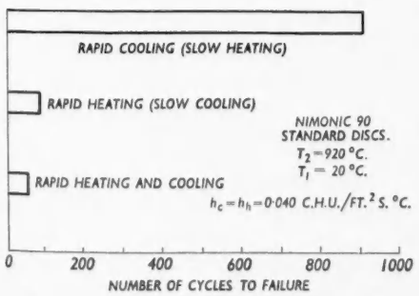


Fig. 14—Effect of nature of cycle on thermal endurance of Nimonic 90

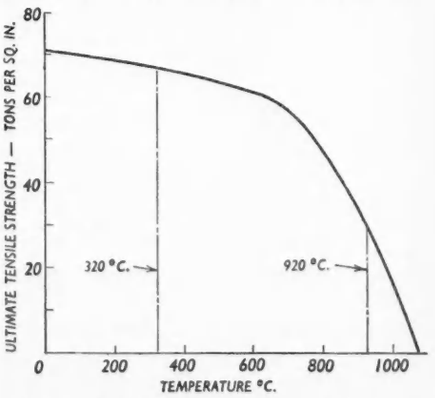
the most interesting finding was that creep resistant alloys of the Nimonic[4] type are much less resistant to rapid heating than to rapid cooling cycles. Fig. 14, showing the comparative thermal fatigue behaviour of Nimonic 90, is typical. The most probable explanation for this behaviour became apparent when temperature distributions during the heating and cooling transients were determined by direct measurement on Nimonic 90 tapered discs, and the thermal strains derived from the temperature differences. On rapid heating from 20 to 920 deg. Cent. a maximum compressive strain of approximately 0·63 per cent was developed at the disc periphery after about three seconds, when the peripheral temperature had attained 700 deg. Cent. If the edge always remained perfectly elastic then the compressive strain during rapid heating would always follow the strain curve indicated by the dotted line in Fig. 15. However, above the limit of elastic deformation for this alloy, plastic straining or upsetting occurred beyond the point at which the strain curve crosses the elastic limit line in Fig. 15. The result of this inelastic process is that when the interior of the disc expanded with rise in temperature, the compressive strain in the edge was relieved and became zero at about fifteen seconds. As the disc interior approached the edge temperature, the edge was then subjected to tensile strains. When both the edge and interior attained a uniform temperature, the tensile strain at the edge equalled the plastic strain in compression. Thus tensile strains and associated stresses were developed in the edge when it is at its maximum temperature, that is, when the material is comparatively weak, as shown in Fig. 16. A similar cycle of events occurs when the blade is rapidly cooled but the tensile strains are developed directly in the edge at lower temperatures when the material is comparatively strong (see Fig. 16).

The effect of varying the upper cycle temperature (T_2) with the lower cycle temperature (T_1) constant on the mean endurance (from at least three tests) of several nickel-based alloys [4, 6, 7] is indicated in Fig. 17. As expected, endurances generally diminish with increase in T_2, although it appears that above a certain temperature, the endurances decrease much less rapidly, and in some cases, remain virtually constant.

It has also been shown that when the temperature difference (T_2–T_1) of the cycle is constant, the value of T_2 is primarily responsible for determining the endurance as indicated in the data given below for Nimonic 90.

T_2 deg. Cent.	T_1 deg. Cent.	$\triangle T$ deg. Cent.	Mean number of cycles to failure from three tests
820	20	800	666
920	120	800	78
1020	220	800	105

The effect of immersion time at T_2 on endurance is indicated in Fig. 18. The endurance diminishes rapidly as the immersion time increases to about sixty seconds, above which the endurance is more or less



U.T.S. values determined at strain rates similar to those incurred during rapid heating and rapid cooling.

Fig. 16—Variation of ultimate tensile strength with temperature for Nimonic 90

constant. Immersion times of less than sixty seconds are insufficient for the mean temperature to attain the edge temperature (i.e. T_2) and therefore a smaller amount of tensile strain will be developed in the edge. At times less than about twenty-five seconds the edge does not attain T_2 and little or no tensile strain is developed during the heating shock. For example, with a ten-second immersion time, the edge and mean tem-

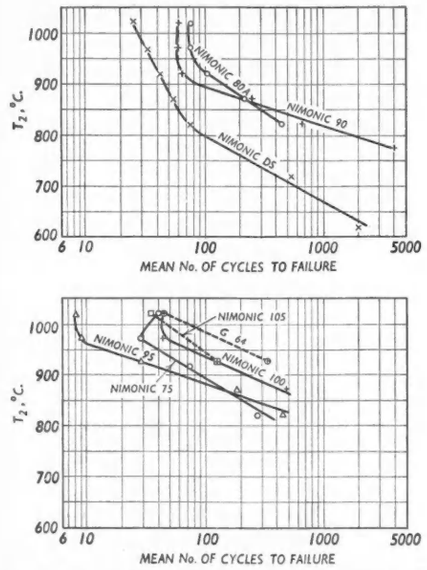


Fig. 17—Variation in thermal endurance with T_2 for test alloys in the form of standard tapered discs

peratures only attain a common value during the subsequent cooling shock.

These observations on the effects of immersion time and of upper cycle temperature on endurance are of considerable importance in connection with the practical problem created by the high transient peaks that are often incurred during " light-up " (i.e. from start to idling) of an aircraft gas turbine.

The effect of environment was assessed by comparing the thermal fatigue behaviour of specimens in air-fluidised and argon-fluidised beds. Although only a few tests have been made, the results (see Fig. 19) indicate that the endurances of Nimonic 90 tapered discs tested in an argon (i.e. very low oxygen content) environment are significantly greater than those obtained in air, whether rapid heating or rapid cooling cycles are involved. The inference from these results is that an increase in the resistance of creep-resistant alloys to oxidation, particularly to intergranular oxidation, is likely to improve thermal fatigue resistance.

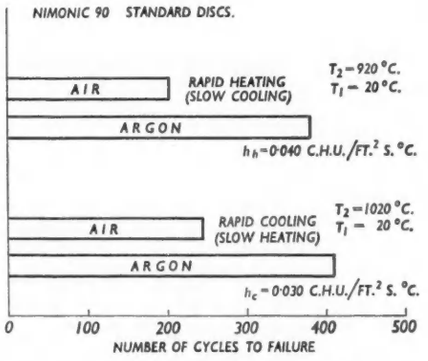


Fig. 19—Effect of environment on endurance of Nimonic 90

The effect of specimen shape on endurance was evaluated. The edge radius of the tapered disc was varied by altering the angle of taper and therefore only slightly altering the size. In Fig. 20 the endurance increases markedly with edge radius up to 0·030in, but there is no significant change on altering the edge radius from 0·030in to 0·040in. These results suggest that the radii at the leading, and particularly the trailing edge (which is often less than 0·020in) of turbine blades will have a significant effect on thermal fatigue life.

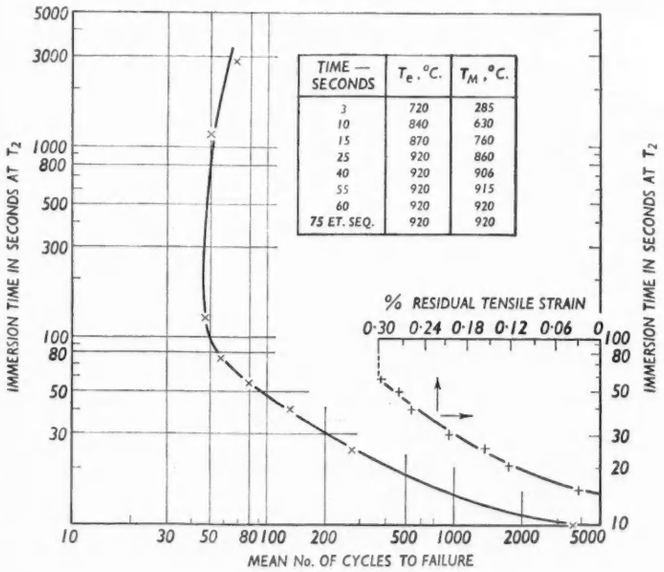


Fig. 18—Variation in thermal endurance of Nimonic 90 with immersion time at T_2

Conclusions

The preliminary studies have yielded useful information on the relative importance of the major factors governing the thermal fatigue behaviour of creep resistant alloys, and have clarified the physical processes leading to thermal fatigue failure. However, the reasons which explain why one material shows superior resistance to another are not clearly understood. Current studies are therefore concerned with relating thermal fatigue behaviour to the metallurgical characteristics and mechanical properties of turbine blade alloys, in particular to their cyclic strain fatigue properties.

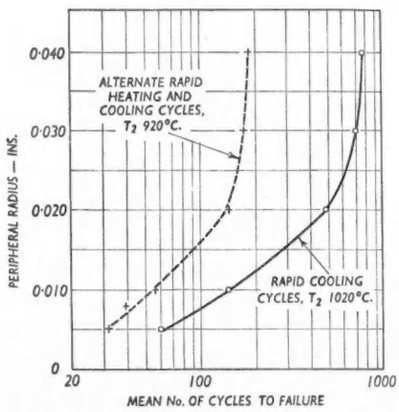

ALTERNATE RAPID HEATING AND COOLING CYCLES, T2 920°C.
RAPID COOLING CYCLES, T2 1020°C.
PERIPHERAL RADIUS — INS.
MEAN No. OF CYCLES TO FAILURE

Fig. 20—Variation in thermal endurance with edge radius of tapered discs in Nimonic 90

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Interchangeability of Shanks and Squares

By D. M. COWLEY*

Why perpetuate a multiplicity of sizes when a simple series of forty squares and shanks would serve for most normal needs ? The author reports, and comments, on a conference held recently at the British Standards Institution, where manufacturers and users of parallel shank tools examined this problem and took a decision on the proposed solution.

IS there any good technical reason why reamers and screwing taps of similar nominal sizes should have different squares ? Or, for that matter, why these and end mills or other parallel shank cutting tools should have different shank diameters ? With or without reason, very many different sizes are now established ; B.S. 949 lists at least eighty shank and square sizes for screwing taps and B.S. 122, Part 2, gives seventy-three different squares, most of those in one standard differing from those in the other. When the innumerable variations appearing in Continental standards are taken into account it is easy to appreciate some of the problems facing manufacturers making for both home and export markets and of users wishing to buy from more than one source.

An important step towards the solution of these problems would be the establishment of a range of squares that could be applied to any parallel shank tools. So thought the International Standards Organisation Committee on Small Tools, I.S.O./TC 29, when it set up a working group to study the question. This group reached the conclusion that the theoretical optimum ratio between the across-flats dimension of the square and the diameter of the shank was 0·80. If this ratio was applied to every possible diameter, however, it would result in an infinite number of square sizes and there would be less standardisation than ever. In order to limit the number of square sizes it therefore became necessary to determine ranges of shank diameters which would ensure that one nominal square size was suitable for any nominal diameter in that range to within ratio limits of 0·75 and 0·85.

After much discussion it was agreed to adopt values based on the R 20 series of Preferred Numbers for the squares and the intermediate values of R 40 series for the diameter ranges. When the square size is associated with the diameter at the midpoint of ranges so determined it is found to afford the theoretical optimum ratio of 0·80, while the ratio between any diameter in a particular range and its corresponding square never falls outside the limits of 0·75 and 0·85. It should be mentioned that the midpoint diameters also fall into the R 20 series of Preferred Numbers.

The values thus established were of metric origin, the inch sizes being direct equivalents expressed to three decimal places of an inch. This was acceptable to the United Kingdom delegation to I.S.O./TC 29 ; the strict interchangeability between inch and metric sizes offered the possibility of achieving a world standard for squares, and since the dimensions for squares are always expressed in decimals of an inch in British Standards, the slight changes in square sizes did not present any great difficulties. In fact, these sizes could be adopted for reamers, taps and so on with no more inconvenience than a relatively small change in a dimensional standard naturally entails. This would in any case soon be outweighed by the fact that the eighty squares for taps and seventy-three squares for reamers, most of them different from each other, would be replaced by forty standard square sizes, all of them completely interchangeable with Continental squares.

Now these squares were associated in theory with diameter ranges (as has been explained) and it was left to each working group responsible for particular tools to select the particular diameters to be specified in its recommendations. Many of the Continental countries, however, felt very strongly that emphasis should be placed on the Preferred shank diameters, which were those representing the mid-points of the ranges, and implied that these should be selected for the international recommendation on reamers, end mills, centre drills and so on. These mean values were those of the R 20 series of Preferred Numbers, 3·15, 3·55, 5·6, 6·3, 7·1, &c. They differed from those at present used in Continental practice—3·0mm, 3·5mm, 5·5mm, 6·7mm, &c.—but many of the Continental countries persuaded their National Committees to accept them on the grounds that their adoption could result in a universal standard since the United Kingdom would be adopting the decimal inch equivalents of these unfamiliar metric sizes.

British manufacturers of small tools who had felt no qualms concerning squares, for the reasons stated above, were less sanguine with regard to these proposals for shank diameters. Fractional inch sizes have been in common use for many years and innumerable machines, jigs, fixtures and other equipment are designed to accommodate these sizes. Although prepared to make whatever was required, they were unwilling to commit the United Kingdom to acceptance of the proposed I.S.O. recommendation without full consultation with users ; and a special conference was accordingly held at the British Standards Institution on July 5 to discuss aspects of this question which most concerned users.

There was a nice balance of manufacturers and users at the conference, which was presided over by Sir Stanley Harley, chairman of the B.S.I. Mechanical Engineering Industry Standards Committee. Discussion was full and frank and the points made can usefully be reiterated here, since one matter on which the conference placed great emphasis was the importance of giving the widest possible publicity to any major changes envisaged for British Standards.

One outstanding advantage of the adoption of the I.S.O. recommendation, with the decimal inch equivalents of the Preferred shank sizes, would be the complete interchangeability thus obtained between inch and metric shanks, and in this connection the Continental countries' willingness to accept metric dimensions different from those in current use must not be overlooked.

As far as practical aspects of the adoption of decimal inch dimensions are concerned, the problems are probably fewer than might at first be supposed. Manufacture presents no special difficulties ; on the contrary, micrometers and other measuring devices are not graduated in fractions of an inch and fractions must inevitably be converted into decimals for checking purposes. It may also be recalled that the British Association Committee, which recently investigated the implications of adopting the metric system, strongly recommended the adoption of decimals in place of the cumbersome fractions at present employed, and there is, in fact, an increasing tendency towards the use of decimals in industry.

Another technical development which should not be ignored in this context is the increasing use of equipment such as adjustable collets and adaptors ; in many cases the differences between the proposed sizes and existing fractional sizes can be accommodated by such devices. Even where this is not the case, much of this equipment is normally regarded as expendable and can be replaced without undue difficulty. It is also worth mentioning that the I.S.O. committees concerned have taken special care to provide close tolerances on shanks and sockets with a view to improving the performance of parallel shank tools.

After hearing all the arguments for and against the proposals, the Conference decided by an overwhelming majority to endorse them as providing a rational series of squares and shank diameters. It is recognised, of course, that the transition period, both here and abroad, may be of fairly long duration and it would be idle to ignore the cost and inconvenience which will be entailed. On the credit side, however, is the simplification which will result : first in regard to British Standards alone, and subsequently in regard to both British and Continental standards, the resultant economies (and in this connection it should be recalled that the costs of the change will be spread over a long period) and the increasing realisation that dimensions based on the Preferred Numbers series of values offer a logical and technically sound solution to many engineering problems.

The decision taken by the B.S.I. conference may therefore be regarded as an important step forward in international standardisation. It is an enlightened decision which recognises that technical justification should take precedence over accepted practice and one which greatly strengthens the position of those who participate in other international work on small tools generally, gaining respect for their arguments abroad and enabling them to report their activities with confidence at home. Finally, when it is realised that " the Six " and " the Seven " have agreed to make use of existing international standardising machinery wherever possible, the importance of the United Kingdom's participation in I.S.O. work cannot be overestimated, and a decision of this kind must be regarded as a positive contribution toward the solution of international standardisation problems.

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LETTERS AND LITERATURE

Letter to the Editor

BRIDGE LAUNCHER OF LIGHT ALLOY

SIR,—Mr. R. B. W. Bolland's comments in your issue for August 12, and in particular his news regarding a 200-ton launcher, were most interesting. In reply, it should be mentioned that the Bailey bridge referred to was not specially adapted. It would be a very lengthy process to analyse the variety of circumstances in which bridge beams have to be placed. Mr. Bolland mentions that cranes can be used for multi-span bridges provided access is possible below and rightly mentions the limitations of height and weight. It is most commonly water which prevents access below and in these cases beams which are too heavy to place with a crane from one abutment can in many cases either be launched across a standard Bailey bridge or either the entire beam or one end only rafted into position. Method can, of course, be affected by many other factors, including tides, but probably once again the main limitations are height and weight. It is suggested that the number of cases in which these limitations will apply is a very small proportion of the total, although it is agreed that where they do apply, the launcher could operate where the cranes could not. The operation illustrated in THE ENGINEER, dated July 1, when this equipment was announced, was apparently a case where no limitations at all applied and work could have proceeded from the abutments or the road below.

Apart from mobility there are two advantages which cranes have compared with special-purpose equipment. The first is that the beams can be brought to the job or moved up from the casting bay and do not have to obstruct the abutment until required. The second is that special-purpose equipment requires care and skill to ensure that everything is precisely positioned. Cranes are much more flexible and capable of adjusting position in all directions.

V. L. HOLLOWAY
Director and General Manager.
Mobile Lifting Services, Ltd.,
Wolverhampton,
August 16, 1960.

Book Reviews

Space Flight. Vol. 1: Environment and Celestial Mechanics. By KRAFFT EHRICKE. D. Van Nostrand Company Ltd., 358 Kensington High Street, London, W.14. Price 109s.

THE Van Nostrand Company has been making a serious effort to provide for students, scientists and engineers a series of reliable works under the broad title of *Principles of Guided Missile Design*. A number of these have already been published and the present volume is a further one. It is the first part of a three-volume work covering the field of Space Flight. Its author is well qualified to deal with the subject, having been associated with practical developments in ballistic missiles and space rockets constantly from the days when he was a member of the Peenemunde "V.2" team to the present time when he is director of the Convair Astronautics space vehicle programme.

Krafft Ehricke is not only a technical authority on his subject, but he is an enthusiast and he does not attempt to minimise his own personal belief in space flight. Indeed, his philosophy is clearly stated that it is one of the fundamental goals of man. He does not prevaricate with suggestions that missile development or scientific research are the important objectives, although he acknowledges that they can be useful in supporting the intermediate steps. Ultimately, man himself will explore space and this will be within a generation. With this philosophy the book is directed towards the discussion of subjects which will be of importance to the astronaut.

The case for space flight is argued in the first two chapters in a very convincing manner, although it is admitted that it relies greatly on military considerations in the initial stages. Even if real disarmament were to arrive, however, there would be advantages in maintaining space rocket projects to prevent a sudden disruption of the guided weapon industry and the consequences upon the economy of a nation. Apart from this there are numerous commercial and cultural benefits to be derived. In addition to the philosophy which is expounded so effectively, these chapters give an excellent history of the progress from the theories of early pioneers to present-day realities and a forecast of the future utility of space flight. The latter goes into considerable detail on the evolutionary process which will lead from instrumental space vehicles to manned space operations and the many new technical and scientific results which may be expected.

By this stage, all but the most sceptical will have accepted the importance and inevitability of space flight, so the author sets about providing the reader with a basic understanding of the solar system in which spacecraft will operate. This he does with the object of preparing for the second part of the volume, which is devoted exclusively to celestial mechanics. He clears away many of the uncertainties and misconceptions that obscure the subject and replaces them with detailed information and tables ranging from the orbital data of the planets to the radiation pressure field of the sun, from the atmospheric data of the earth to the topography of Mars, and from data on meteoric dust particles to the nature of comets.

Although the first half of the book is important and valuable in its own right, it is clearly intended as a lead-in to celestial mechanics which is, in turn, the foundation for an understanding of space flight mechanics. It is divided into a discussion of the central force field, orbit determination and perturbation analysis. These are naturally treated more from the viewpoint of the astronautical scientist than that of the astronomer. They involve a reasonable ability to follow mathematical discussion, but are by no means too involved for graduate students. Problems are set at the end of each chapter and solutions are provided. These help both to supplement the information presented in the main text and to give the reader a better understanding of the techniques.

Perhaps the most important chapter is the final one on perturbations, because it introduces the problems of precision navigation. These will usually be non-periodic, as when passing a celestial body during transfer from one orbit to another. Thus the treatment has been restricted to the special perturbation method, a stepwise integration, as a more practical if less elegant analysis.

This appreciation of practical requirements is found throughout the book and adds much to its value. It adds confidence that this is not merely a theoretical study of space flight, but carefully selected material which will be of real value to the student.

Methodes topologiques appliquées à l'electronique. By L. SIDERIADES. Publications Scientifiques et Techniques du Ministère de l'Air, No. N.T.84. Paris: Magasin C.T.O.: 2, Avenue de la Porte—d'Issy, Paris (15e). Price Fr.3190.

"TOPOLOGICAL METHODS IN ELECTRONICS" is concerned with non-linear systems of the first and second order, the analysis of which is illustrated by examples drawn from the field of electronics. In the mathematical study of plane systems of the first order, matrix notation enables singular points to be defined in a novel manner by means of eigenvalues. The spectrum of a system is defined, and the integral curves are graphically traced. Applications include oscillators and flip-flops of the classical kind, as well as novel systems such as flip-flops with four equilibrium positions, systems with gyroscopic coupling, and multi-vibrators with continuous and discontinuous operation.

Roads and Their Traffic. By ERNEST DAVIES. Blackie and Son, Ltd., 16-18, William IV Street, London, W.C.2. Price 35s.

ALTHOUGH there has been a great deal of road building and road widening in recent years, the flow of new vehicles off the assembly lines has been so great that traffic congestion has become steadily worse. This state of affairs has brought to birth the science of traffic engineering and the profession of traffic engineer; as evidence of its interest the Institution of Civil Engineers has formed a Traffic Engineering Study Group, and the Institutions both of Municipal and Highway Engineers include this subject in their scheme of examinations.

This book, *Roads and Their Traffic*, is thus very timely. As an introduction to the subject it will prove helpful both to the student thinking of taking up traffic engineering as a career and to the qualified civil engineer who is finding that traffic engineering problems are taking up more and more of his time and who is finding it increasingly necessary to make a serious study of the subject. It is not a textbook or work of reference as ordinarily understood by the practising engineer, but is a compendium of articles by leading experts.

The main job of a traffic engineer is so to plan things in his area, usually within a very limited financial budget, that the traffic can move as quickly and as safely as possible. In deciding what to do it is always useful to

know how particular problems have been tackled in other areas. The general editor of the book, Ernest Davies, has clearly had this in mind. The twelve principal chapters of the book have each been written by a specialist in a particular field of the subject; they include three county surveyors, three city engineers and three well-known foreign experts. Mr. Davies has planned the whole work and provided an introduction and a summary of conclusions.

The whole subject is first sketched in outline by Professor John Hugh Jones of the Northwestern University of Illinois. The late Professor Feuchtinger then, " to show how closely science and practice are interwoven in the realm of traffic engineering," deals in detail with three urban problems (*a*) a complex road intersection, the Jahnplatz Bielefeld, (*b*) a cramped medieval city, Utrecht, (*c*) an extensive area, the Cologne-Bonn Region. This chapter is of great value in showing just how the urban traffic engineer goes to work ; it is written in simple and lucid English.

The next three chapters provide a great deal of useful information about the part that motorways can play in the traffic system of a country. In the first of these three chapters James Drake, County Surveyor of Lancashire, deals with motorways in Great Britain. The second chapter, by M. de Bussy, formerly director of the Rijkswaterstaat, Holland, discusses national and regional motorways in Continental Europe; and in the third chapter H. Hondermarcq, Director-General of Roads, Ministry of Public Works and Reconstruction, Brussels, treats the subject of urban motorways in the light of both general practice and his special experience in Brussels.

In succeeding chapters Sir Herbert Manzoni, City Engineer of Birmingham, deals with urban traffic control, and Mr. Nicholas, City Surveyor of Manchester, then discusses the problem of parking. Both provide much useful background information.

The final chapters are concerned with road signs and markings, road lighting, research, administration and safety, the respective authors being Mr. K. Summerfield, the County Surveyor of Oxfordshire, Mr. Granville Berry, the City Engineer of Coventry, Dr. G. Charlesworth, Head of the Traffic Section of the Road Research Laboratory, Mr. S. Maynard Lovell, the County Surveyor of the West Riding, and Major-General B. K. Young, the former Director-General of Ro.S.P.A. Each is valuable as an introduction to the subject. The chapter on research is of value not only as a concise summary but as a guide to further reading. Most of the other chapters also include useful biographies and the book has a good index. The layout, the printing, the binding and the other details of book production are unobtrusively good. The standing and authority of its contributors and the skill of its general editor, Ernest Davies, have combined to make this book a useful beginning to any serious study of the subjects it treats. Basic knowledge and experience in traffic engineering is growing rapidly and the traffic engineer having read the book will want to supplement his knowledge from the many papers now being published.

Pilkington Brothers and the Glass Industry. By T. C. BARKER. George Allen and Unwin, Ltd., 40, Museum Street, London, W.C.1. Price 40s.

WINDOW glass is one of the necessities of modern life which is so commonplace that nobody notices it. Like most of the things we have come to accept as indispensable window glass was at one time—and not really all that long ago—neither so abundant nor of such quality as it is now. In fact, for 150 years, up to the middle of the nineteenth century, window glass was officially regarded as a luxury, and was taxed accordingly.

Glass-making needed more than repeal of a tax and enlightened views on its use before it could develop into an industry. It needed many technical developments, and the glass works needed good management. How those developments came about, and how the trade grew to its present scale of operation, are told in the present book. It is a story which becomes, as it progresses, increasingly the story of one family, the Pilkingtons of St. Helens, for although other names appear, and the author pays due attention to them, Pilkingtons came, in the course of time, to dominate the industry, technically and commercially. To-day, the firm is the largest manufacturer of glass in the British Commonwealth and one of the biggest family businesses in the world. Window glass is not the only concern of the Pilkington business ; the company and its subsidiaries are engaged in the manufacture of certain other glass products as well. But window glass is its main product, and it is with this that the book is mainly concerned.

William Pilkington, the founder of the present glass-making business, had no knowledge of the trade at all. He was the son of a St. Helens doctor who was also a wine and spirit merchant, and when William was invited, in 1826, to join a newly-formed partnership for making window glass, it may well have been that he was looked upon as a sleeping partner, valued only for the capital he brought in. William, however, was not the sort of man to be content with merely investing his money in a business. He was soon taking a very active part in the management, and it has been a major characteristic of the Pilkington family ever since that those who went into the business were always active in one branch or another ; sometimes in more than one department.

The transition from the somewhat primitive, " hand-made " conditions in the glass trade when William Pilkington entered it, to the present highly mechanised plants operated by the firm to-day has involved the engineer as much as the glass maker. Mechanisation was something the Pilkingtons were ever ready to try, and very large sums of money were spent by the firm at various times in its history. The outstanding example of this is, of course, the development, at a cost of £4,000,000, of the revolutionary " float " process for producing glass in a continuous wide ribbon, which was brought to a successful conclusion about twelve months ago.

People, plant, processes, finance, all play their part in the building of a successful business, and it is very easy for the historian to pay too much attention to one particular aspect or another. Dr. Barker has skilfully avoided this danger, and has produced a balanced account in which the various facets are seen in proper perspective.

It is particularly gratifying to see due attention paid to purely technical matters. Like all specialised trades glassmaking has its own technical terms, and some explanation of them is necessary to a proper understanding of the subject. That explanation is provided. The reader does not have to struggle through the text wondering what is the difference between broad, crown and plate glass, nor is he left in doubt about the meaning of such terms as " marver," " punty " and " flashing." It is true that this is how a business history ought to be written, but all too often it is not. Dr. Barker has set a good example to other writers.

Der Deutsche Ingenieur in Beruf und Gesellschaft. V.D.I.-Information No. 5. September, 1959. Düsseldorf : Verein Deutscher Ingenieure, Prinz-Georg-Strasse 77-79 (orders for copies to : Abteilung Organisation). Price DM.2.

THE brochure, No. 5 of *V.D.I.-Information*, sets out in detail the results of an inquiry made by the Association of German Engineers towards the end of 1956, into the social status of the professional engineer in the German Federal Republic. Some of the chief findings have already been published (see *V.D.I.-Nachrichten*, *Vol* 11 (1957), Nos. 20, 21 and 24). Nearly 34,000 members of V.D.I. were sent a thirty-three question circular to be filled in anonymously ; some 71 per cent did so. It is not possible here to do more than mention briefly some of the points investigated. These range from distribution according to district, age, and branch, to training, professional position, size of employing company, salaries, family status, choice of career, profession of parent and of children, financial circumstances, and the relationship of the individual concerned with his group. As hardly any statistical material of this nature had previously been available the present publication helps to fill a serious gap in our knowledge.

Books Received

English-Polish Dictionary of Mechanical Engineering. Edited by S. Czerni. Panstowe Wydawnictwa Techniczne, Warsaw. Price zl98.

Unusual Locomotives. By Ernest F. Carter. Frederick Muller, Ltd., Ludgate Honse, 110, Fleet Street, London, E.C.4. Price 21s.

Beyond the Planet Earth. By Konstantin Tsiolkovsky. Pergamon Press, Ltd., 4 and 5, Fitzroy Square, London, W.C.1. Price 15s.

Applied Electricity. Fifth Edition. By H. Cotton. Cleaver-Hume Press, Ltd., 31, Wright's Lane, Kensington, London, W.8. Price 25s.

The Young Engineer. By Charles B. Broschart. Phoenix House Ltd., 38, William IV Street, Charing Cross, London, W.C.2. Price 12s. 6d.

Heat and Thermodynamics. Fifth Edition. By J. K. Roberts. Revised by A. R. Miller. Blackie and Son, Ltd., 17, Stanhope Street, Glasgow, C.4. Price 45s.

Progress in Cryogenics. Vol. 11. Edited by K. Mendelssohn. Heywood and Co., Ltd., Carlton House, Great Queen Street, London, W.C.2. Price 63s.

Electrical Who's Who 1960-1961. Sixth Edition. Electrical Review Publications, Ltd., Iliffe and Sons, Ltd., Dorset House, Stamford Street, London, S.E.1. Price 35s.

Design of Modern Steel Structures. Second Edition. By Linton E. Grinter. The Macmillan Company, 10, South Audley Street, London, W.1. Price 45s. 6d.

Aircraft and Missile Design and Maintenance Handbook. By Charles A. Overbey. The Macmillan Company, New York, and 10, South Audley Street, London, W.1. Price 68s.

Water Engineers Handbook, 1960. Twenty-Eighth Publication. Edited by D. Wilkinson and N. Squire, The Colliery Guardian Company, Ltd., 30-31, Furnival Street, Holborn, London, E.C.4. Price 20s.

Plastics Engineering Handbook of the Society of the Plastics Industry, Inc. Third Edition. Reinhold Publishing Corporation, New York. Chapman and Hall., Ltd., 37 Essex Street, London, W.C.2. Price 120s.

Woods Practical Guide to Fan Engineering. Edited by W. C. Osborne and C. G. Turner. Woods of Colchester, Ltd., Essex. Price 17s. 6d.

Design and Performance of Gas Turbine Power Plants. Vol. XI, *High-Speed Aerodynamics and Jet Propulsion.* Edited by W. R. Hawthorne and W. T. Olson. Oxford University Press, Amen House, Warwick Square, London, E.C.4. Price 105s.

Union Castle Liner R.M.S. "Windsor Castle"

The liner "Windsor Castle," designed for the passenger and mail service of the Union Castle Mail Steamship Company, Ltd., to South Africa, recently sailed on her maiden voyage. A total of 882 first and tourist class passengers is carried, and the ship has a service speed of 22½ knots. Propulsion is by two sets of double-reduction geared turbines of 45,000 total shaft horsepower taking steam at 600 lb per square inch gauge and 950 deg. Fah. from three watertube boilers.

NOW on her maiden voyage to South Africa in the passenger and mail service of the Union Castle Steamship Company, Ltd., is the R.M.S. "Windsor Castle," which was built and engined by Cammell Laird and Co. (Shipbuilders and Engineers), Ltd. This is the third ship to bear the name of "Windsor Castle," the first, of 2672 tons, being built by Donald Currie in 1872, while the second was a liner of 18,967 tons launched in 1921, driven by turbine machinery, and sunk in 1943. The keel of this latest addition to the fleet was laid on December 9, 1957, and the ship was launched at Birkenhead on June 23, 1959, by Her Majesty Queen Elizabeth, the Queen Mother. From our illustration it can be seen that the liner has a raked soft-nosed stem, cruiser stern, and well rounded midship superstructures, surmounted by a large streamlined funnel and a streamlined signal mast. The following are the main particulars of ship :

Length overall...	783ft 3in
Length between perpendiculars ...	730ft
Breadth moulded	92ft
Depth moulded to "C" deck ...	50ft
Draught maximum...	32ft
Gross tonnage...	38,000
Service speed	22·5 knots
First class passengers	191
Tourist class passengers...	591
Interchangeable, first class ... ... or tourist class ...	50 / 100
Crew...	475
Maximum persons on board... ...	1357
Propelling machinery :	
Double-reduction geared turbines of Pametrada design ...	Two sets
Total normal service power ...	45,000 s.h.p.
Propeller revolutions per minute	115
Babcock and Wilcox boilers ...	Three
Steam supply	600 lb/square inch gauge at 950 deg. Fah.
Electrical machinery :	
W. H. Allen turbo-generators ...	Three
Rating	1500kW, 225V
Diesel generators...	Three
Rating	1000kW, 225V
Diesel emergency generators ...	Two
Rating	100kW, 225V

Apart from the superstructure decks there are four complete steel decks, namely, "D," "C," "B" and "A," which extend for the full length of the ship within the main hull together with Orlop and Lower Orlop decks forward and aft of the machinery spaces. Subdivision is effected by twelve watertight bulkheads which, with the exception of the aft peak, rise to "C" deck, and are fitted as required with Stone's watertight doors which are electrically operated from the bridge and locally. Doors above the waterline are hydraulically operated. Other subdivision is by fire-resisting bulkheads which divide the hull and superstructure into zones. The double bottom is arranged to carry fresh water or water ballast and oil, fuel and there is provision for additional fresh water in tanks to port and starboard of the shaft tunnels, while deep tanks, located forward of the auxiliary engine-room, carry oil fuel. For the prevention of fouling it is of interest to note that F. A. Hughes and Co., Ltd., has equipped the ship with its "Toxion" system of anti-fouling, and that this is associated with cathodic protection.

Accommodation

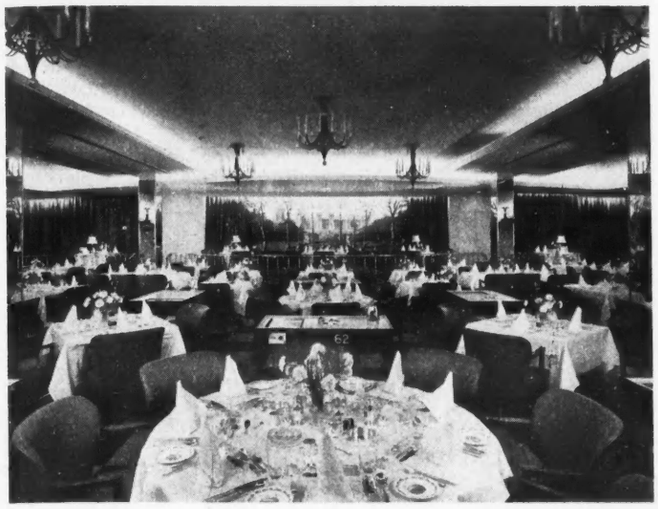
The first class passengers are accommodated in single- and two-berth cabins, arranged to port and starboard amidships on "C" deck, forward of midships on "D" deck, and in a number of two-berth de luxe cabins to starboard on "E" deck. Each cabin has a private bathroom. On both "C" and "D" decks there is a total of twenty-five cabins which are interchangeable and provide accommodation for fifty first class or 100 tourist class passengers. Glass doors from a lobby lead into the dining room, illustrated opposite, which seats 268 passengers at tables for two, four, six or eight and which has the deck stepped up at the sides with the raised areas separated from the centre by a crystal "Perspex" and brass balustrade. Three murals mounted in the forward bulkhead form the main decoration. There is an associated small private dining room for private parties. The public rooms are on the promenade deck with the lounge forward and having a raised platform at its forward end, which serves as an observation platform during the day. We include a view of the lounge looking aft from the observation platform. To port aft of the entrance is the smoke room, while to starboard is the drawing room arranged in country house style. Further aft is a circular card room and the library, then the verandah café divided from the swimming pool by folding glazed screens. Adequate space is available for games and there is a sun roof over part of this area. Considerable use has been made of cold cathode fluorescent tubing, supplied by The General Electric Company, Ltd., for the illumination of the public rooms.

For the tourist class passengers there are two-, three- and four-berth cabins arranged aft on "A," "B," "C" and "D" decks and a "U"-shaped dining room on "B" deck. The public rooms for this class are on "E" deck with a lounge, having a centrally placed and recessed dance floor, right forward and looking out on to a partially covered sun deck. A corridor, to port, leads aft and opening off it are a library and writing room and a smoke room which is divided into three, each section having its individual and distinctive layout and decoration. Continuing aft there is a covered promenade and dancing space and then a lido, swimming pool, verandah café, and right aft a children's playing space. The dining saloon, of which we include an illustration, is on "D" deck and seats 334 passengers at tables for two, four, six, eight or ten, with banquette seating at the ship's side.

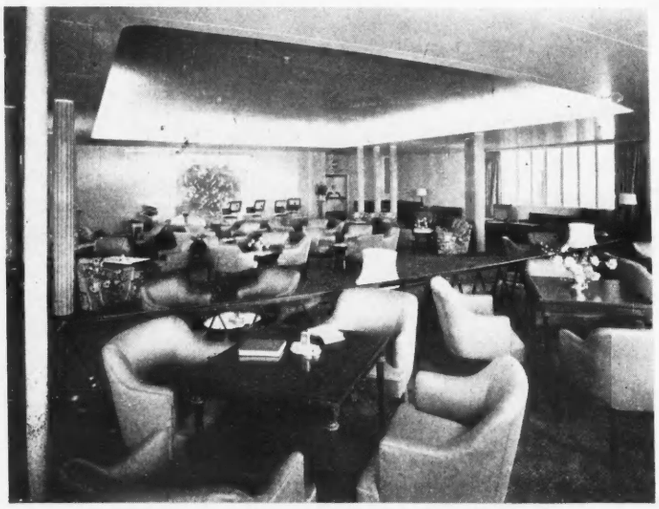
A cinema having 250 seats and equipped with a wide screen is arranged just aft of amidships on "C" deck. In addition to the usual medical facilities the ship is equipped with a spa which provides for massage and special baths.

The captain, staff captain and chief engineer have suites on the captain's bridge; there are cabins for officers on the bridge and boat decks, together with a dining room and a smoke room on the latter deck. On "C" deck are cabins for the ship's staff, warrant and petty officers, and forward is a covered promenade and a recreation room for the crew. Greasers and seamen, &c., have quarters on "B" deck forward, while the stewards are generally accommodated in four-berth cabins forward on "A" deck. Mess spaces are on "B" deck near to the crew's galley.

All the cabins for the passengers and crew are air-conditioned and the system also serves the dining saloons, cinema, shopping centre, and hospitals. Individual control is provided for first class and officers' cabins while the tourist and crew accommodation is divided into zones with the air-conditioning units being fitted with fin tube heaters which operate for the whole zone. Thermotank, Ltd., has manufactured and installed the equipment, and the air is distributed by "Coronet" distributors and "Stripline" grilles. The installation has a capacity of 10,500,000 B.Th.U. per hour and requires a total of 520 fan b.h.p. There is a comprehensive mechanical exhaust system for the public rooms, kitchens, laundry, &c. All the public rooms, excluding those which are air conditioned, are mechanically ventilated and heated and there is a system of mechanical supply of air at atmospheric temperature



First class dining saloon looking forward



First class lounge looking aft from observation platform

to the kitchens, laundry, garage, steering gear compartment, refrigerating machinery space. Spot coolers are fitted in the kitchen and food preparation rooms.

Equipment

There are seven holds and associated 'tween decks for the carriage of cargo, of which three are forward and four aft of the machinery rooms. General cargo is carried in numbers 1, 2, 6, and 7 lower holds, the remaining holds and 'tween holds being arranged for the carriage of refrigerated cargoes. A garage is arranged in "D" deck in way of number 2 hatch. A 2-ton Clarke Chapman deck travelling crane serves numbers 1 and 2 holds and at number 7 hatch there are two 10-ton derricks, while the deck machinery includes five "Scott" 3-ton electric winches of which three have been arranged for load speeds down to 40ft per minute for breaking out cargo. The remaining hatches are intended to be served by shore cranes. For handling the anchors there is an electric windlass, while for mooring purposes three electric capstans are sited aft and three forward, all manufactured by Clarke Chapman and Co., Ltd. Brown Brothers and Co., Ltd., has supplied the steering gear and also sets of stabilisers; one set complete with pumps is located at the forward end of the engine-room and the second set is placed forward in the generator room. Both first and tourist class passengers are served by lifts supplied by J. and E. Hall, Ltd. The lifts for the first class passengers both rise from "D" deck, one stopping at the promenade deck and the other stopping at the bridge deck. Both the tourist class lifts rise from "A" deck to "E" deck. The same manufacturers provided the escalator and the refrigerating machinery. The ship-side gangway doors, of which there are six, are all actuated hydraulically, using a system designed by Short Brothers and Harland, Ltd.

There is a well-equipped laundry right aft on "C" deck, and the ship's fire protection arrangements include a Mather and Platt automatic sprinkler system, CO_2 fire extinguishing equipment by W. Kidde and Co., Ltd., "Marinite" bulkheads, linings and ceilings, &c. To deal with sewage the ship is fitted with plants provided by Adams Hydraulics, Ltd. Lifesaving appliances include eight 36ft, one 31ft and two 26ft lifeboats fitted with hand-propelling gear and one 31ft motor-driven lifeboat, all built of "Birmabright" by Hugh McClean, Ltd., fitted with Schat skates and carried under Taylor gravity davits. There are, in addition to the conventional buoyant apparatus manufactured by Linkleters, Ltd., a number of inflatable life rafts supplied by R.F.D. and Co. Ltd. Marconi International Marine Communications Company, Ltd., S. G. Browne, Ltd., Kelvin Hughes and Co., Ltd., have provided the navigational instruments, while Clifford and Snell, Ltd., has installed the comprehensive control console which is mounted in the wheelhouse.

Main Propelling Machinery

The line drawing overleaf shows the general arrangement of the three machinery spaces, and we also include illustrations of the engine and boiler rooms. In the engine-room there are two independent sets of compound condensing double-reduction double-helical geared turbines designed for steam conditions, at the superheater outlet, of 600 lb per square inch gauge at 950 deg. Fah. Each set consists of h.p. and l.p. turbines arranged so as to ensure simplicity of overhaul, and each develops 22,550 s.h.p. at 115 propeller r.p.m.

The h.p. ahead turbines, of all impulse design, have nine stages: steam is admitted through three groups of nozzles, of which one is uncontrolled, the remaining two having individual valves so as to ensure most economic running under a range of power conditions. To reduce thermal distortion the nozzle chests are separate castings so welded into the main cylinder as to permit radial expansion. Integral with the h.p. ahead turbine is the two-row Curtis wheel astern turbine, which is overhung from the forward bearing and housed in a separate casing. Bled steam is extracted after stages one, three, six and nine, and to simplify the extraction all inter-stage diaphragms are located in carriers supported from the outer cylinder. Isolating valves connect the extraction points after stages one and three so that under low power steam can be bled from the higher pressure point and extracted after stage three under higher power conditions. At normal horsepower the h.p. turbine speed is 5231 r.p.m. The double casing, single flow, impulse-reaction, l.p. turbines exhaust into two-flow Weir "Regenerative" underslung condensers having a total tube area of 35,000 square feet. There are four impulse stages followed by five reaction stages, and blade carriers extract water at the sixth, seventh and eighth stages. The l.p ahead turbine rotates at 3277 r.p.m., and housed within the ahead casing but in a separate cylinder supported by palms and radial keys is the l.p. astern turbine.

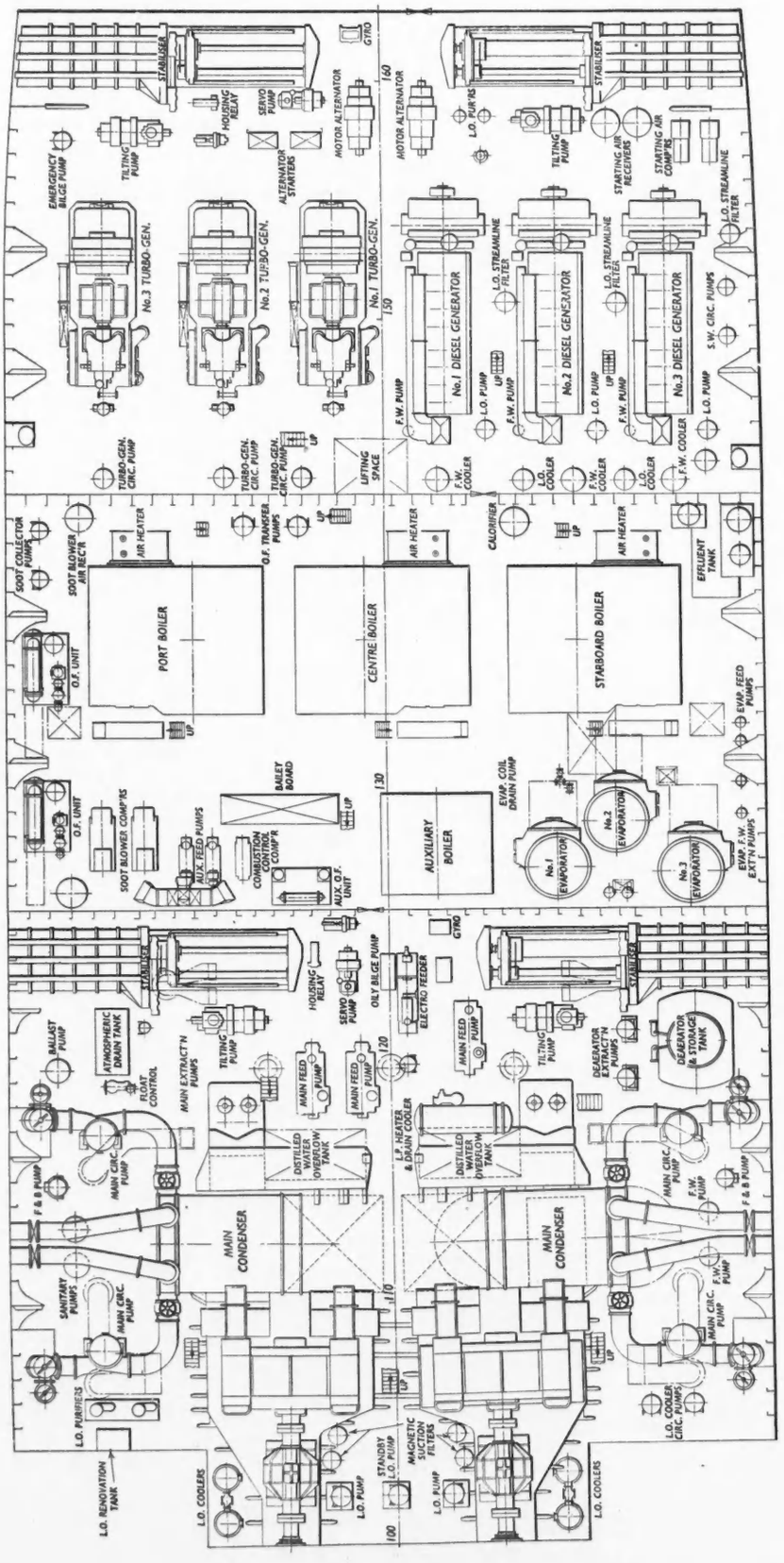
A Michell thrust block is bolted to an extension of each gearcase seating and the shafting is carried in Michell bearings, while the propellers, of 21ft 6in diameter by 23ft pitch, have four blades and are of "Nikalium."

To handle the lubricating oil there are three motor-driven Drysdale pumps, each rated at 40,000 gallons per hour at 45 lb per square inch plus 10ft static lift. Also in the system are four Serck coolers, four

Tourist class dining saloon

Philips magnetic strainers, four A.K. Strainers, two 1400 gallons per minute oil-cooled circulating pumps, and two Alfa Laval purifiers, each of 350 gallons per hour capacity.

In addition to having the normal array of gauges the main engine control panel, provided by Bailey Meters and Controls, Ltd., incorporates a " Mimic " layout, showing in diagrammatic form the condensate, feed, bled steam, evaporating and lubricating systems.



General arrangement of machinery spaces

Steam Plant

Three single-furnace, Selectable Superheat boilers of Babcock and Wilcox design provide steam at 600 lb per square inch gauge and 950 deg. Fah.: each has a normal evaporation rate of 125,000 lb per hour, increasing to 156,000 lb per hour at maximum load. Babcock and Wilcox oil-burning equipment is employed, and each boiler has seven " Iowa " burners and one pilot burner fitted with Lucas torch ignition. A desuperheater element at each drum has an output of 20,000 lb per hour at 570 deg. Fah. Each boiler has a Green's gilled tube primary economiser, a secondary stud tube economiser and two-stage Serck air heaters, while the all-welded alloy steel superheaters are of multi-loop design supported on water-cooled tubes to which are clamped heat resisting alloy steel finger plates. For these, different metal treatments and special alloy steels have been incorporated for research purposes.

Furnace lining and floor are of materials provided by Morgan Refractories, Ltd., and the generator tubes are of cold drawn E.R.W. steel, while the downcomers and uprisers are of seamless steel.

Automatic air-puff soot blowers are mounted with provision for manual adjustment to cater for sequence blowing; the system includes air compressor soot blowers of 75 cubic feet per minute capacity at 100 lb per square inch, an air receiver of 120 cubic feet capacity at 210 lb per square inch, and soot collector water pumps delivering 150 tons per hour against a 200ft head. There are three wet upflow Howden dust collectors, each rated to handle 76,000 cubic feet of gas per minute at 380 deg. Fah., having a resistance of 2·4in water gauge and using 155 gallons of water per minute. Open stokehold conditions operate and the boilers work under Howden's system of forced and induced draught, there being three f.d. fans, each driven by a 134 h.p. 1450/750 r.p.m. Laurence Scott motor and each rated at 51,000 cubic feet per minute at 130 deg. Fah. against 9·9in water gauge. Each i.d. fan can deliver 76,000 cubic feet of gas per minute against a pressure drop of 16in water gauge when driven at 1055/550 r.p.m. by a 290 h.p. Laurence Scott motor.

Bailey Meters and Controls, Ltd., provided the automatic control equipment and for cleaning the internal and external boiler tube surfaces there are Davies and Metcalfe ejector units. Cyclone steam evaporators are fitted to the steam drums and Vortex inhibitors are placed at the inlets to the front and rear downcomers. Boiler mountings include Dewrance consolidated safety valves, Bailey feed-water regulator, Ronald Trist high and low water alarms, " Igema " distant reading water level indicators, Klinger water level indicators with Dewrance bi-colour water level gauges. Cockburn main stop valves are fitted and Hopkinson, Ltd., has supplied the isolating and main manoeuvring valves.

An oil-fired auxiliary boiler of Babcock and Wilcox sectional header pattern is installed for use in port and has a capacity of 30,000 lb per hour of dry saturated steam at 120 lb per square inch gauge. The boiler supplies the normal hotel services, which at sea are met by a horizontal Weir steam/steam generator which has a surface of 800 square feet and produces 30,000 lb per hour at 60 lb per square inch gauge using 33,000 lb at 240 lb per square inch absolute. There are two " Iowa " burners with " Y " jet steam pressure atomisers, a Howden f.d. fan rated to deliver 11,000 cubic feet per minute of air at 100 deg. Fah. against 7·6in water gauge, and a dry upflow dust collector

to deal with 18,500 cubic feet of gas per minute. Automatic control equipment is fitted, also automatic air-puff soot blowers, safety valve, water regulator, and level alarms and level indicators.

Condensate from the main machinery is delivered to the main boilers through a Weir four-stage regenerative closed feed heating cycle. The four condensate extraction pumps, two working and two standby, are of " Lo-Hed " vertical electrically driven units, each having an output of 170,000 lb per hour at 56 lb per square inch gauge when running at 1350 r.p.m. Direct operated valves control the discharge from the extraction pumps, and the two " Maximac " twin element, two-stage steam jet air ejectors maintain a vacuum of 27·75in Hg when extracting 62·6 lb of air per hour. In the system are an l.p. heater and drain cooler having an area of 1550 square feet and 333,601 lb per hour capacity, and two water heaters capable of raising 414,305 lb per hour of condensate successively to 325 deg. and 370 deg. Fah. Two 375,000 lb to 487,500 lb per hour two-stage feed pumps supply the main boilers, and also installed is a three-stage 185,000 lb to 350,000 lb per hour pump and an electrically-driven ten-stage pump of 66,500 lb per hour capacity ; all are able to deliver against a pressure of 800 lb per square inch gauge. The de-aerating plant includes a " Concentric " pattern de-aerator, a devaporiser, two 52,000 lb per hour extraction pumps, control valves and a flash chamber. Other Weir auxiliaries fitted are a condensate circulated distiller and a chemical injection pump.

Cooling water for the main condensers is provided by four 1400 gallons per minute Drysdale pumps and an auxiliary pump of 50 tons per hour capacity.

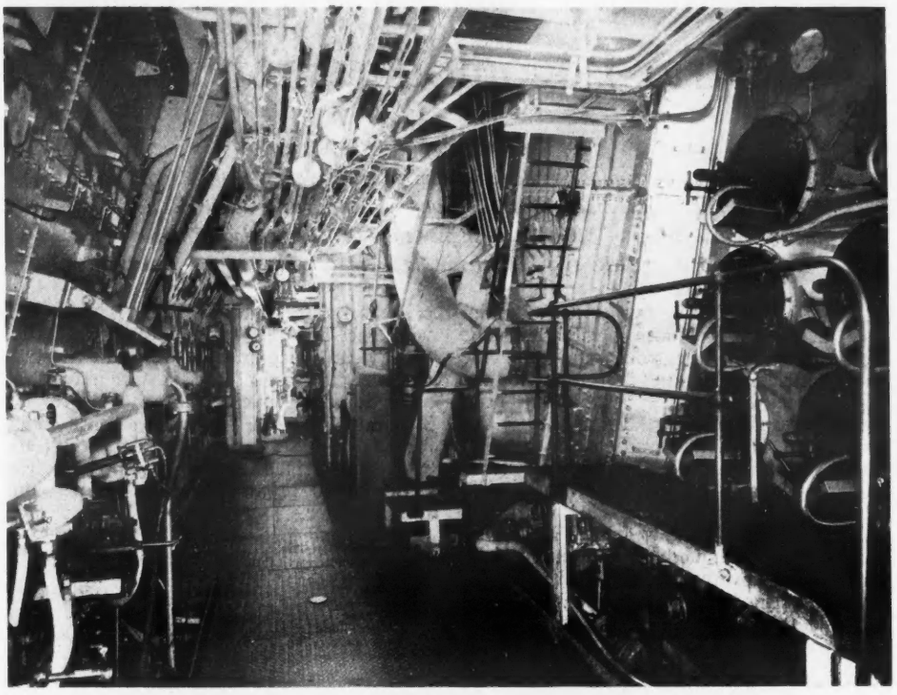
Machinery Auxiliaries

The sea-water distillation plant is capable of producing 250 tons of distilled water per twenty-four hours and consists of three evaporators, a cooler and a condenser, a preheater, a steam jet air ejector, also two fresh water pumps and brine and evaporator feed pumps. Make-up feed water is treated in a " Deminrolit " plant and the domestic water is passed through a CO_2 hardening plant. The majority of the pumps are motor-driven, and Worthington Simpson, Ltd., has provided a 215-145 tons per hour, 120ft–230ft head ballast pump, two bilge and fire pumps and an emergency bilge pump of similar rating. For the transfer of boiler oil there are two 100 tons per hour pumps, while for diesel oil transfer there are two 20-ton per hour pumps, all supplied by Drysdale and Co., Ltd.

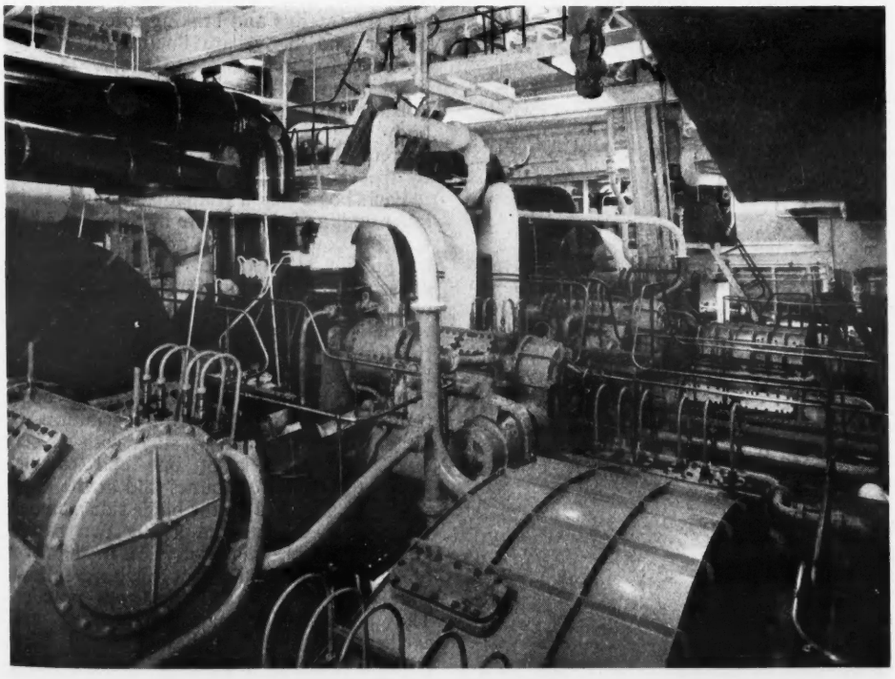
Electrical power demands are met by three 1500kW, 225V d.c. generators, driven through parallel shaft speed-reducing gears by multi-stage high efficiency turbines manufactured by W. H. Allen, Sons, and Co., Ltd. Steam is supplied at 560 lb per square inch gauge and 940 deg. Fah. and exhausts to self-contained condensers, complete with air ejector, extraction and circulating pumps, at a vacuum of 29in Hg when using cooling water at 60 deg. Fah. The turbines run at 6000 r.p.m. and are geared to the generator speed of 550 r.p.m. On the starboard side of the generator room are three 1000kW, 225V generators, intended for use in port, driven by Harland and Wolff pressure-charged four-stroke diesel engines, complete with pumps and crankcase extraction fans. For emergency purposes there are two 100kW diesel-driven generators mounted on the bridge deck. Power is distributed from main and emergency switchboards supplied by A. Watson and Dundas Company, Ltd.

The cold cathode lighting equipment was provided by The General Electric Company, Ltd., and is supplied from two 120kVA, 240V motor alternators.

Ventilation of the machinery spaces has been specially considered, and four 45in fans, each rated at 35,880 cubic feet per minute, supply the engine-room, and six fans of similar capacity serve the boiler-room, while two 50in fans of 47,000 cubic feet per minute capacity supply the generator room, and in addition there is a 55in axial flow fan for the tunnel spaces. All the fans were manufactured by Davidson and Co., Ltd.



View across boiler fronts, auxiliary boiler on left



General view of engine room

Obituary

We have learned with regret of the death on August 14 of Mr. W. G. Martin, overseas manager of A. Reyrolle and Co., Ltd. Mr. Martin was fifty-six. He joined Reyrolle's in 1926, and assisted his father, the late Mr. David Martin, the company's representative in Scotland. On returning from war service in 1945 Mr. Martin was appointed Reyrolle Scottish manager, having charge of the company's activities throughout Scotland. He returned to Hebburn in 1956 to assume the post of deputy overseas manager until 1958, when he was appointed overseas manager. He was a director of A. Reyrolle and Co. (SA) (Pty.), Ltd., and of A. Reyrolle and Co., (Rhodesia) Ltd.

Electric Locomotives for South Africa

In a mixed traffic design for service on all the electrified routes of the South African Railways, provision is made for multiple-unit working on the heavier duties, while the individual rating of 2200 h.p. is higher than that of previous four-axle locomotives on the S.A.R. system and widens the field of unassisted operation.

AFTER introducing two series of main-line electric locomotives with three-axle motor bogies in the post-war years, the South African Railways returned to the B_0-B_0 wheel arrangement which had been used on the Natal electrification since 1925. Progress in mechanical and electrical design had meanwhile placed the four-axle locomotive on nearly equal terms with six-axle designs in respect of capability in traffic, while saving notably in weight. The policy was therefore adopted of ordering lighter locomotives, slightly less powerful individually than the largest ones previously employed but able to work in multiple unit on the heavier duties.

One of the orders placed in this connection was for 135 B_0-B_0 locomotives to be supplied by the Metropolitan-Vickers Electrical Company, Ltd. As a result of subsequent reorganisation, the contract is now the responsibility of the Traction Division of Associated Electrical Industries, Ltd. Deliveries of these locomotives, one of which is seen in Fig. 1, are in progress, and numbers of them are already at work in Natal. One hundred are being built at the Stockton works of Metropolitan-Vickers-Beyer, Peacock, Ltd. The other thirty-five are under construction by the Metropolitan-Cammell Carriage and Wagon Company, Ltd., as sub-contractor to A.E.I. Traction Division.

These 3ft 6in gauge, 3000V d.c. locomotives, classified "5E1," weigh 84·5 tons for a one-hour rating of 2200 h.p. The individual motor rating of 550 h.p. compares with 500 h.p. in the earlier series of South African Railways "5E" locomotives (described in our June 17, 1955, issue); and with the 505 h.p. motors of the $1C_0$-$C_0$1 "4E" class locomotives, which at the time of their introduction in 1952 were among the most powerful which had been built for the 3ft 6in gauge. The "5E1" class is intended for mixed traffic service on all parts of the S.A.R. electrified system and has a top speed of 60 m.p.h. Principal dimensions and characteristics are :

Length over couplers	50ft 10in
Height to pantograph (housed)	13ft 5in
Pantograph working range	7ft 2in
Overall width	9ft 6in
Bogie wheelbase	11ft 3in
Pivot centres	25ft 9in
Total wheelbase	37ft
Wheel diameter	4ft
Tractive effort	26,000 lb at 26·5 m.p.h. (continuous)
	32,000 lb at 24·5 m.p.h. (one-hour)

The locomotive body is of welded construction, with side members carrying part of the normal underframe loads. It is clad with preformed sheeting tacked to the framework at $\frac{5}{16}$in spacing and then layer-welded. The cab is built as a separate tee-iron welded structure. Preforming of side and front plates, cab roof corners and other shapes is carried out on an Eckold press, no panel-beating being employed. The underframe is also welded and is formed of a centre girder with outriggers and longitudinals. Two cross-members carry the bogie centres and lifting brackets, and the drag-boxes are welded at each end. Bogies are of the one-piece cast-steel "Commonwealth" design of the English Steel Corporation, Ltd., with coil springing for the primary and secondary suspension. Each equalising beam is sprung from the bogie frame by two springs and carries the axleboxes working in normal horn guides. Two brackets slung by swing links outside the bogie frame carry the coil springs, two at each side, on which the ends of the bolster rest (Fig. 2). The links allow lateral movement of the bolster amounting to about 4in in each direction. Hydraulic dampers are fitted between the equalising beams and the bogie frame, as well as between the bolster and the swing brackets. The suspension is exceptionally soft but adequately controlled.

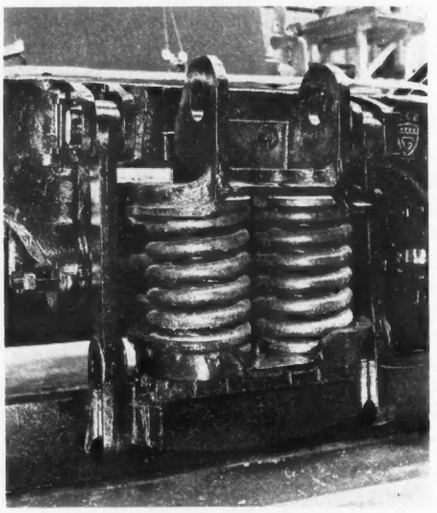


Fig. 2—Swing bracket outside bogie frame supporting bolster through coil springs

Tractive and braking forces are transmitted between the bogie and the bolster by means of a draw-buff rod at each side, located at axle level to minimise weight transfer. The bolster ends of the rods are clamped between rubber pads and the opposite ends have rubber-bushed attachments to lugs on the bogie frame, these rubber attachments allowing for the normal swing bolster movements. The bogie centres, which rest in the bolster centre pivots and take the tractive and braking forces between bolster and body, are lined with "Ferobestos" for resistance to wear. Lifting brackets on the body register with lugs at the bolster ends and are bolted thereto when the body is in position. There are no side bearers, the whole body weight being taken by the centre pivots.

Each bogie has a triangular linkage at its inner end, and the two are interconnected by a spring coupling. This arrangement assists in guiding the bogies into curves, with consequent reduction in flange and rail wear, but transmits no tractive forces.

The traction motor nose suspension takes the form of a short link, rubber-bushed at both ends, between a nose bracket on the motor frame and a bracket on a bogie transom. Side movement of the motors on the axles is restrained by stays with rubber-bushed connections at one end to lugs bolted to the motor frames and at the other to brackets formed on the bogie side member.

Roof equipment, comprising two pantographs and lightning protection in the form of arcing horns and a capacitor, follows standard South African Railways practice. The pantographs may be isolated and earthed by roof switches operated from ground level by means of hooked poles. The main power circuit is shown in Fig. 3, in which it will be seen that the traction

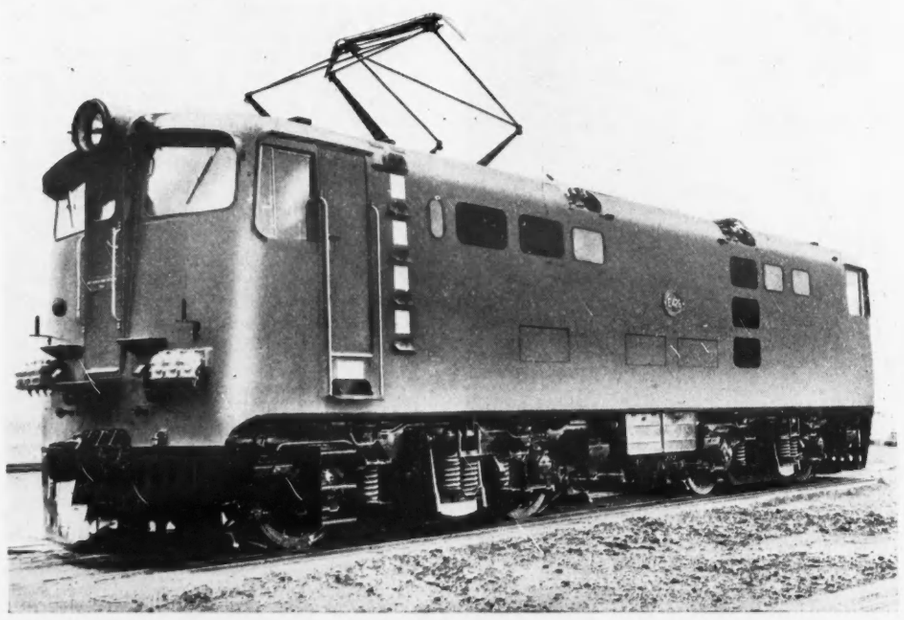


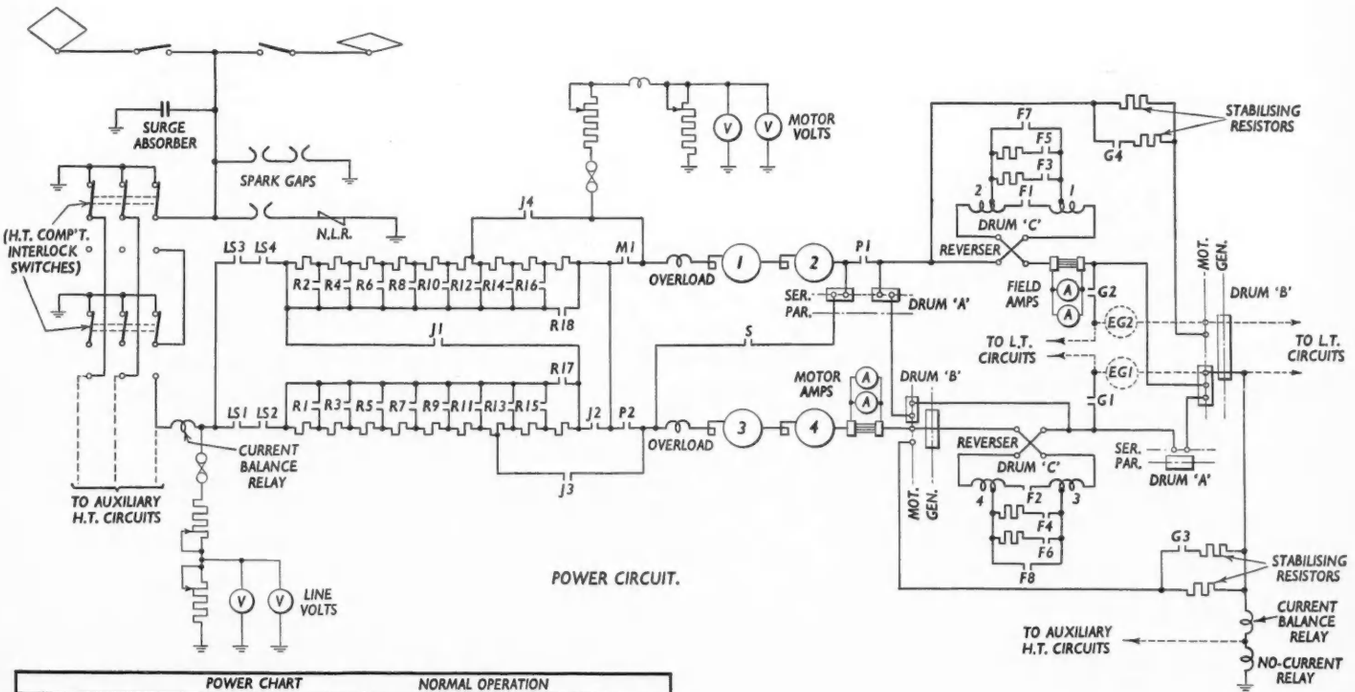
Fig. 1—Mixed traffic B_0-B_0 locomotive for the 3000V d.c. electrified lines of the South African Railways

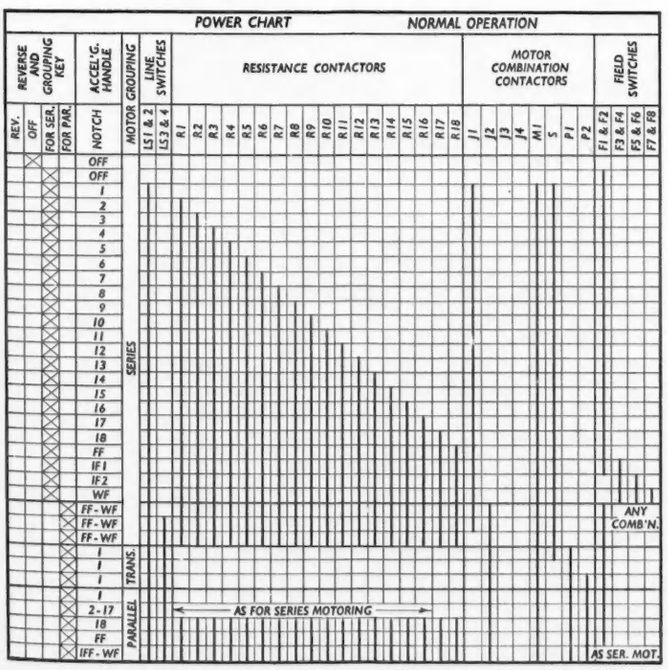
motors, being wound for 1500V, are permanently connected in series pairs, the locomotive being controlled by series or parallel grouping of the two pairs of motors. Three weak-field steps may be used in each grouping, and regenerative braking is available both in series and parallel, covering a speed range of approximately 60 to 20 m.p.h. Resistance notching and field-weakening are effected by individual electro-pneumatic contactors. Reversal, transition, and the change-over between motoring and regeneration are controlled by three electro-pneumatic drum switches. In series the resistances are cut out in eighteen steps, and in parallel in seventeen steps.

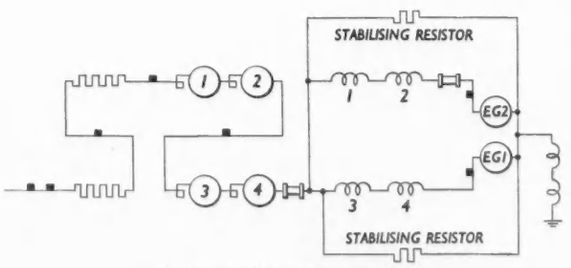
The weak-field resistors are non-inductive, but it will be seen from the diagram that on each weak-field step a portion of each field is in series with the divert resistance, giving the equivalent of a diverter in series with an inductive shunt. On the third weak-field step both diverter resistances in each motor field group are short-circuited by the closing of contactors *F*7 and *F*8, the reduction then being due to the tappings only. The simultaneous opening of *F*1 and *F*2 avoids shorted turns in the portions of the fields which have been tapped out.

Fig. 3 also shows the connections of the traction motor armatures in series and parallel pairs for regenerative braking, together with the excitation arrangements. It will be seen that in the parallel connection there are two independent excitation circuits, one supplied from each half of the exciter. If the regenerated voltages across each pair of armatures are unequal for any reason, there is no path for circulating currents to flow between them and hence no interference with the stability of the braking effort. Sixteen braking notches are available in each grouping by control of the exciter ouput. When operating as an exciter the maximum output from each half of the machine is 55V.

The main control resistances are of the company's R.P. type, of edge-wound alloy strip. They are continuously force-ventilated while the locomotive is motoring, but the rate of air flow is reduced automatically when resistance notches are not in use. Fig. 4 shows the location of the resistance compartments and their blowers in the locomotive body, together with the other equipment. Air is drawn in through " Air-maze " filters in the body sides and passes upwards over the resistances to roof outlets. In the general view of the locomotive (Fig. 1), the filters are identifiable as the three louvred panels in the body side arranged one above the other. Should a blower fail, the resistance bank affected may be cooled by natural air flow by opening panels low in the body side which uncover screened openings direct into the resistance compartment. This







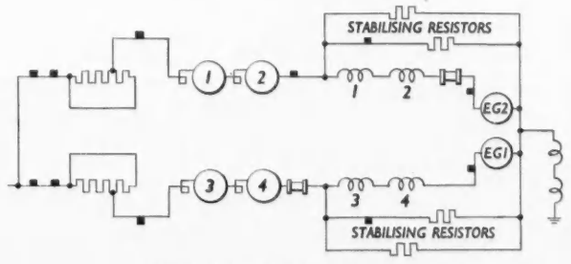


Fig. 3—Power circuits and notching chart for motoring; the basic connections for regenerating in series and parallel are also shown

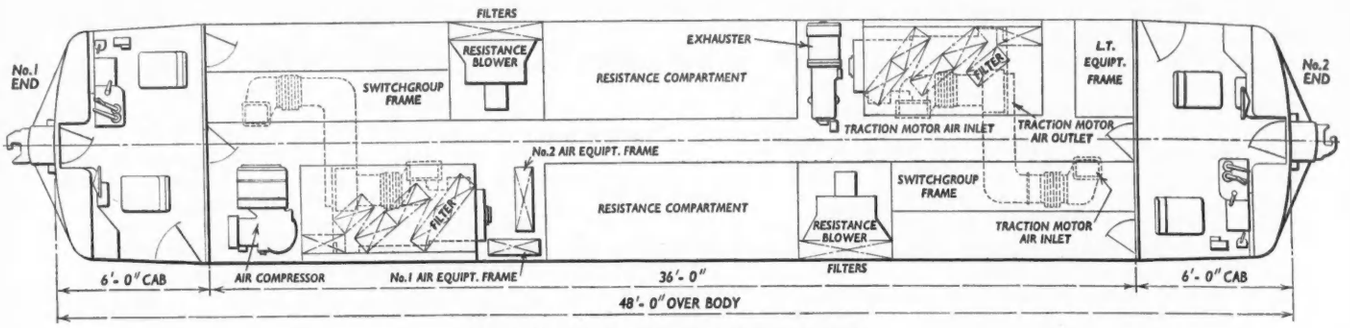


Fig. 4—Layout of equipment in locomotive body

operation is carried out from a centre corridor by means of a winding handle. The blowers are visible from this corridor so that their operation can be checked in the event of an auxiliary failure being signalled by the warning light fitted for this purpose in each cab. Communication between the driving cabs is by means of this corridor, (Fig. 4) and access is possible from this to the rear of the h.t. switchgroup frames, when the pantographs are earthed, by removing panels interlocked with the protective equipment. The two short corridors into the h.t. compartments themselves are protected by doors which cannot be unlocked until the circuits have been isolated and earthed.

The blowers are 23in diameter Keith Blackman axial fans driven by 5·5 h.p. A.E.I. motors at 2840 r.p.m. when running at top speed, but slowing to 950 r.p.m. when the resistances are not in circuit. Air delivery at top speed is 8500 cubic feet per minute. The supply for both resistance blowers is taken at 75V from the exciter motor-generator set. Providing the traction circuits are set up for motoring, the resistance blower motors start as soon as the field contactor of the exciter motor-generator set closes. When the main controller handle is on a resistance notch they run at full speed, but on other notches contactors open to insert resistance so that the motors are supplied at 15V and operate at low speed.

The traction motors are four-pole machines. Armature and field windings have glass and mica insulation treated with silicone varnish, contributing to the high output obtained in these locomotives from machines which have to be confined within the space available between the wheels of a 3ft 6in gauge bogie. This involves a short core length and a relatively large armature diameter. Ventilation is at the rate of 3000 cubic feet per minute per motor from centrifugal fans overhung on the exciter and supply motor-generator sets. Two filter panels for the intake to one of these blowers are seen to the right of the roof access ladder in Fig. 1. The motors have sleeve suspension bearings. They drive through resilient gearwheels incorporating "Silentbloc" bushes between rim and centre, and provision is made for removal of the pinions by oil injection. Ratings are as follows :

	A	R.p.m.	S.h.p.
Continuous, full-field ...	260	688	471
Continuous, weak-field ...	260	904	471
One-hour, full-field ...	305	648	550
One-hour, weak-field ...	305	810	550

Motor characteristics are shown in Fig. 5.

Fig. 6 shows the operating handles of one of the master controllers. The motor grouping is selected by moving the reverse key to one of its "forward" positions. Acceleration is controlled by moving the right-hand lever round its quadrant step by step, pressing the push button in the end of the handle if it is desired to enter the weak-field notches. When the locomotive has been notched up in series to full-field or beyond, the reverse key is free to be moved to "parallel." The accelerating lever is then moved back to its first power notch, while holding the push button in. This prevents inadvertent return to the "off" position, and on reaching notch 1 the transition to parallel takes place automatically. If the locomotive has been coasting and is still running at not less than 25 m.p.h., power may be restored by moving direct into the parallel notches.

To begin regeneration the accelerating lever is returned to "off," the desired motor grouping selected, and the regenerating control (left-hand lever) is moved away from "motoring" and operated in its quadrant until the same readings are shown by the regeneration and line voltmeters on the instrument panel. Return of the accelerating lever to full-field then recloses the line contactors and cuts out resistance so that the motor armatures are connected direct to line. The driver's instruments consist of vacuum and air brake gauges, speedometer, motor ammeter (with centre zero to show regenerated as well as motoring current), motor field ammeter (showing the level of excitation during regenerative braking), line voltmeter, and armature voltmeter.

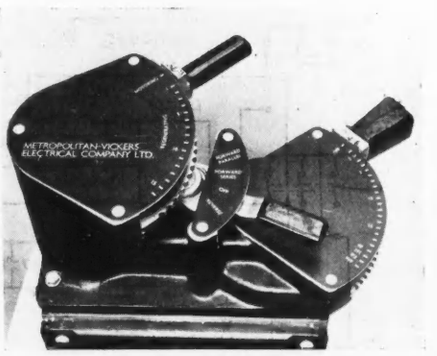


Fig. 6—Arrangement of accelerating, motor grouping/reverser, and regenerating handles on master controller

There are two motor-generator sets per locomotive, each supplied at line voltage and designed to provide power for the regulated low-voltage system and excitation for the traction motors during regeneration. The two resistance ventilating fan motors are also supplied by the exciter set. Both motor generators are identical in construction, the wide difference in output being accommodated by a double winding on the generator armature. When running as a supply set the windings are connected in series and when as an exciter set the windings are connected in parallel. Should the supply set fail, the exciter set can be reconnected by the driver with its armature windings in series to provide the necessary supply set power. The motor is of two-pole construction with a compound field system and split main poles to provide rapid response to transients on the line.

The locomotive brakes are air-operated, compressed air for this purpose and for the

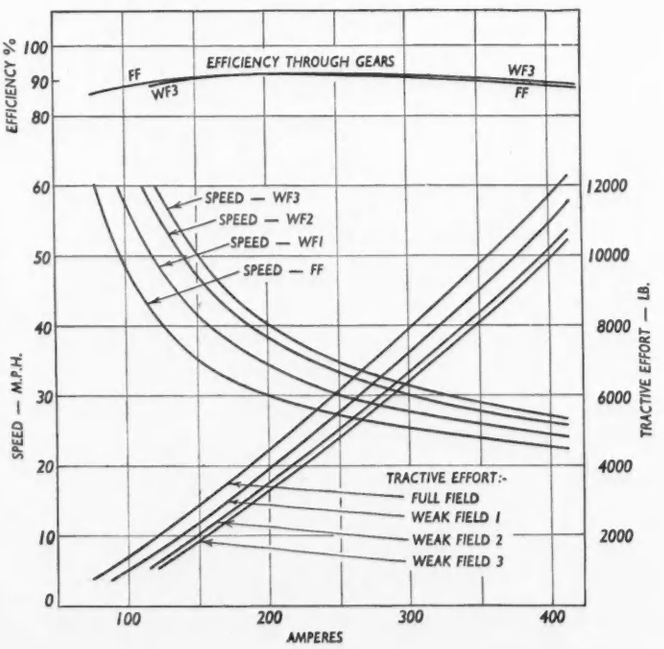


Fig. 5—Traction motor characteristics at 1450V

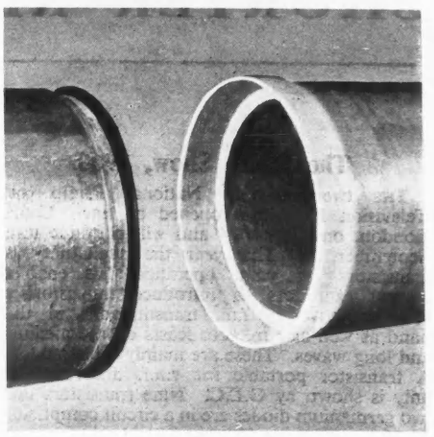
control equipment, sanders, and other services being supplied by a Westinghouse CM38 single-stage compressor. This is a two-cylinder, longitudinal in-line machine with integral A.E.I. geared motor drive. A Reavell R6x8 exhauster provides the vacuum for the train brakes. It is a bedplate-mounted machine driven by an A.E.I. motor and has a displacement of 14 cubic feet per minute when running at 1400 r.p.m. for releasing the brakes, when it absorbs 6½ b.h.p. For maintaining vacuum it runs at 940 r.p.m. and absorbs 4¼ h.p. When running at 1400 r.p.m. the exhauster will create in forty seconds a vacuum of 20in Hg. in a 32 cubic foot vessel. with a $\frac{5}{16}$in diameter leak, and will maintain this vacuum with a $\frac{1}{4}$in leak at 940 r.p.m. A proportional valve enables the locomotive air brakes to be applied automatically in proportion to the train vacuum brakes if desired. If necessary, lighting and essential services can be supplied from a battery charged from the supply motor-generator set. A 110V outlet is provided on the locomotive for connection to the control circuits of a train-heating boiler in a separate vehicle which may be coupled at the head of a passenger train. Provision is also made for working in multiple-unit with another locomotive.

Glass-Fibre-Reinforced Concrete Pipes

THE very high tensile strength of glass fibres has often been remarked upon by engineers (notably by Freyssinet) interested in improving the technology of reinforced and prestressed concrete, and glass fibres have, from time to time been suggested as a favourable medium for transmitting the tensile forces which are normally sustained by reinforcing rods or prestressing wires. As far as we are aware, the idea has always remained rather nebulous, but last week we were invited to see a new product in which practical success has actually been achieved in an application of this kind, namely, in the manufacture of pipes. Basically, this idea consists of strengthening a pipe made of unreinforced concrete, using normal spun concrete techniques, by winding glass fibres round it and coating them with polyester resin. When this has been done, the pipe is heat-treated to set the resin.

The result is a pipe with a "skin" which is resistant to tensile forces, the strength of the composite pipe depending on the number of windings of fibre placed round it and the angle at which the helix of fibre is wound on. The behaviour of such a pipe under load is unusual and is in some ways analogous to that of a prestressed concrete pipe. It is the usual practice to relate the design and performance of such pipes to their failing load for a "two-edge" loading test, i.e. with equal and opposite point loads at each end of a diameter ; in practice, this means applying a vertically-downward load along the axis of a pipe positioned in the test rig. Under these conditions tensile cracks form in the concrete at the top dead centre and bottom dead centre positions on the cross section of the pipe, the cracked concrete behaving as a pair of two-pinned arches. However, it is emphasised by the makers that such cracking is the normal behaviour of the pipe under load, and is not detrimental in any way, for the plastics skin of the pipe ensures that it remains watertight even under the condition just short of ultimate load when the two cracks have extended to the full depth of the concrete. The recovery of the pipe when load is removed is quite remarkable, and the cracks close and disappear. At the ultimate load (for the pipe demonstrated) the concrete failed in compression at the points orthogonal to the two tensile cracks, and the glass fibre and resin came away as a separate skin. We were informed, however, that the bond between the resin and the concrete plays an important part in the behaviour of the pipe, and is not destroyed until very close to the ultimate load.

Application of the skin of glass and plastics to the pipe is somewhat expensive relative to the cost of the concrete, so the uses for which these pipes are likely to be employed are those which would otherwise call for "thick wall" (i.e. reinforced) concrete pipes or steel or iron pipes—that is to say, where there is an internal hydrostatic pressure, or where the superimposed load outside the pipe, due perhaps to its depth below the surface, is heavy. It is thought they will prove competitive with "extra strength" reinforced concrete pipes in the range of diameters of 18in-42in. Complete absence of corrosion is clearly to their advantage, and recovery when load is removed makes them suitable for conditions where loads may change, e.g. where traffic may occur over the pipeline after some years, or mining subsidence be possible. Resistance to sulphate attack is a further advantage, and a light wrapping can, in fact, be put on standard pipes for this purpose alone.

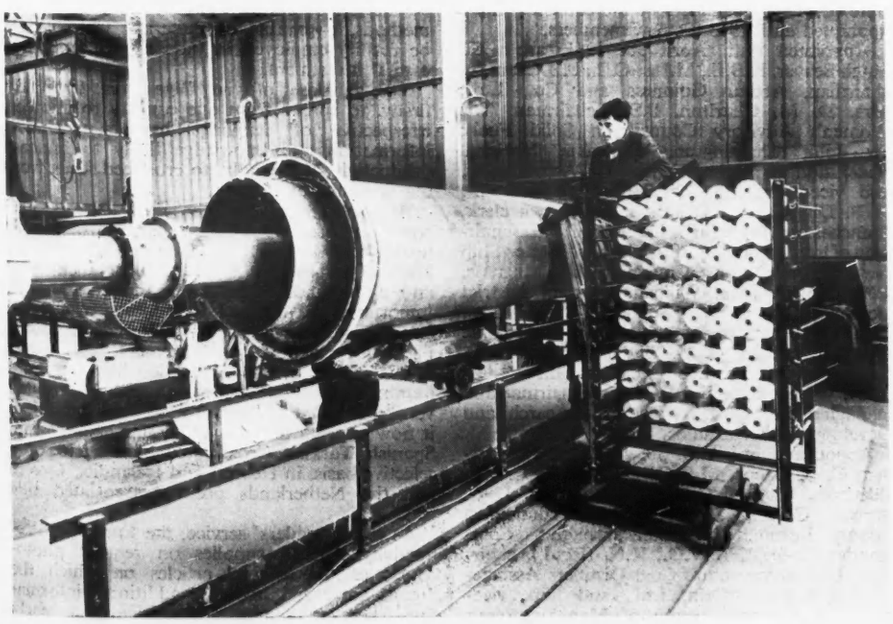


The elements of the flexible joint, with the socket end, formed entirely of resin and glass fibres, on the right. The spigot end (which has a slightly sharper taper than the socket) and the rubber sealing ring are on the left

The first illustration herewith shows the glass fibres—which are in the form known as glass fibre rovings—being wound on to a 24in pipe, whilst the resin is spread from a bath and roller, the bath moving along under the rotating pipe ; on the far side, an operative with a roller works on the pipe to ensure satisfactory spreading of the resin.

The second illustration shows the type of joint which has been developed for these pipes. As can be seen the socket is entirely of fibre and plastics, its internal surface being made accurately on a metal former, to a taper. A taper—slightly sharper than the taper inside the socket—is also accurately formed on the plastics coating on the spigot end. A rubber ring is placed over the spigot taper, and the two pipes are then forced together. The joint has withstood 150 lb per square inch without leakage under test, and it is considered practicable to use it for a working pressure of 75 lb per square inch, with up to 3 deg. of slew and $\frac{3}{8}$in of draw on each or any joint. Thus, together with the recovery of the pipe when load is removed, the whole construction is flexible.

Pipes made in this manner are known as "Deckon" pipes, and they are made by Sharp, Jones and Co., Ltd., at Parkstone (Poole), in Dorset. They are acceptable to the Ministry of Housing and Local Government as far as loan sanction of drainage and water schemes is concerned, for what is termed "class B" pressure.



Winding the glass rovings and applying polyester resin to the exterior of a 24in concrete pipe

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

MINERAL-INSULATED CABLES PART 1 : COPPER-SHEATHED CABLES WITH CONDUCTORS

No. 3207 (Part 1) : 1960. Price 5s. Mineral-insulated cables were standardised dimensionally in the 1949 edition of B.S. 883, "Cables and flexible cords for electrical equipment of ships," but this new publication is the first British Standard to give a complete specification for such cables, with tests. The dimensions are the same as those given in B.S. 883 : 1949, but they are no longer related to drill sizes and are now stated as standard values with positive and negative tolerances. In the new standard the cables formerly known as 250V cables are classified as 440V cables. The 660V classification remains unchanged. Both classes are suitable for use at the stated voltage between conductors or between conductors and sheath. The cables covered by the first part of the new standard have copper conductors and copper sheath, with provision for an outer PVC covering when required. It is hoped to publish eventually additional parts dealing with other conductor materials and different types of sheath.

SHORTER REPORTS

The Radio Show, 1960

THE twenty-seventh National Radio and Television Exhibition opened at Earls Court, London, on August 24 and will continue until September 3. This year the availability of transistors for v.h.f. operation has enabled several exhibitors to introduce transistorised receivers covering f.m. transmissions in this band as well as a.m. broadcasts on the medium and long waves. These are mainly table models. A transistor portable for v.h.f./f.m. reception only is shown by G.E.C. Nine transistors and two germanium diodes are in a circuit comprising an r.f. amplifier, oscillator-mixer, three i.f. stages operating at 10·7 Mc/s, ratio detector, and a three-stage audio amplifier. This receiver is equipped with a built-in retractable aerial. The 9V battery has a life of 150 hours to 300 hours. Dimensions of the receiver are 8¾in high by 13½in wide by 3⅞in deep, and the weight is 5¾lb. Among developments in television receivers is the incorporation of light-sensitive cells to control picture contrast according to room lighting conditions. Makers incorporating this facility include Philips, McMichael and Sobell. The new " Brimar " 23in tube is seen in receivers by Ferguson and Kolster-Brandes.

A co-operative display of transistor techniques and applications has been arranged by the industry. Three items of interest here are transistorised navigational devices for small ships, comprising a steering control operating on the servo loop principle, a depthmeter, and a radio compass. In the last-named instrument a magnetic compass is incorporated in the aerial head so that bearings can be read directly relative to magnetic North when the aerial has been adjusted for zero signal. On the stand of Standard Telephones and Cables, Ltd., the advent of tunnel diodes for experimental purposes is represented by a demonstration of one of these devices operating under water as a 10 Mc/s oscillator. The oscillatory circuit is formed of resistance wire and provides the bias for the diode. Two silicon diodes from the new S. T. and C. range for television receiver rectifiers are being subjected to a surge of 35A every five seconds throughout the show: their rated maximum current is 500mA.

In the non-commercial section, the Post Office display is built round progress in 300 years of communications. The Dollis Hill research station has an exhibit showing the experimental application of magnetic memory cores and transistors to metering calls. This arrangement, applicable to any form of exchange where it could be justified economically, would permit interrogation of the memory at any time and the printing-out of answers. Services stands show telecommunications activities, devices for navigation and charting, and equipment used in electronics training.

Local Broadcasting and Radio Links

VISITORS to a three-day exhibition arranged by Pye, Ltd., Cambridge, at the Royal Festival Hall on August 22 to 24 could inspect a local broadcasting station of the kind proposed for providing independent radio service in large towns and cities throughout the country. The transmitting equipment comprised a v.h.f. transmitter for continuous service and a m.f. transmitter to be used during daylight hours only, to avoid interference from the sky wave after dark. Another exhibit recalled the " moon-bounce " signal to the United States last year, an experiment of renewed interest in the light of the recent launching of the U.S. communications satellite. While the input power for the signal via the moon was low, a very high aerial gain was necessary, the transmission being made from the Jodrell Bank radio telescope. A passive satellite a few hundred miles above the earth allows communication with more conventional aerial systems, and further reduction in aerial dimensions would be possible with a satellite-borne repeater, a project now being studied by Pye, Ltd. Such systems would avoid the uneconomic use of power, sensitivity to upper atmosphere conditions, and interference with local television reception which are associated at present with tropospheric scatter working. All these methods of communication, however, have the common aim of being line-of-sight frequencies for long-distance transmission and so taking advantage of the multiplicity of channels that can be accommodated.

A model was shown of the 7000 Mc/s London-Birmingham microwave link now carrying vision and sound programmes for Associated Television, Ltd. The overall path length is some 135 miles, and the longest hop is approximately 52 miles, On this section passive reflectors are used on a 200ft tower at Barkway to provide a path clear of obstructions, the amplifying and repeating equipment and paraboloids being at the base of the tower. The route also carries a v.h.f. link with engineers' and telemetering channels. It is stated to be the first long-distance trunk television circuit in Britain to be installed and operated by private enterprise, and the first permanent radio link of its kind to operate in the 7000 Mc/s band.

Clean Air Council Appointments

ALL the initial appointments having expired, Mr. Henry Brooke, the Minister of Housing and Local Government, has appointed the following people to be members of the Clean Air Council. In order to start a system under which roughly one-third of the appointments will expire each year, it has been arranged that some of the appointments will expire in 1961, some in 1962 and some in 1963. Those who have been appointed for periods ending in 1961 or 1962 were previously members of the council ; those appointed until 1963 are new members.

Appointed until April 30, 1961, are : Sir Hugh Beaver, K.B.E., M.Inst.C.E., M.I.Chem.E., chairman, Arthur Guinness and Co., Ltd.; Mrs. D. M. Charlton, B.Sc., chairman, The Women's Advisory Council on Solid Fuel ; Sir John Charrington, chairman, National Federation of Coke Distributors Associations, and vice-president, Coal Utilisation Council ; P. B. Dingle, Esq., C.B.E., LL.M., town clerk, Manchester; R. S. MacTier, Esq., C.B.E., chairman of technical committee, Liverpool Steam Ship Owners' Association ; Councillor F. V. Magness, J.P., vice-chairman, Willenhall Urban District Council ; Dr. S. W. Saunders, Ph.D., B.Sc., F.R.I.C., chairman of I.C.I. (Heavy Organic Chemicals), Ltd.; C. M. Vignoles, Esq., C.B.E., managing director, Shell-Mex and B.P., Ltd.; A. H. Wilson, Esq., F.R.S., deputy chairman and managing director in charge of Research and Development, Courtaulds, Ltd.

Appointed until April 30, 1962, are : Alderman C. A. Bence, M.R.C.S., L.R.C.P., C.St.J., alderman, City of Cardiff ; Councillor J. A. Brown, C.B.E., J.P., F.R.S.H., councillor, County Borough of Middlesbrough ; Commander C. Buist, M.V.O., R.N. (Retd.), chairman, Low Temperature Coal Distillers Association of Great Britain, Ltd., and hon. vice-president, National Union of Manufacturers ; Sir Josiah Eccles, C.B.E., D.Sc., deputy chairman, Central Electricity Authority ; Lieut.-Col. The Lord Dudley Gordon, D.S.O., M.I.Mech.E., member of council and executive committee, British Iron and Steel Federation ; K. W. C. Grand, Esq., member, British Transport Commission ; Dr. W. A. MacFarlane, C.B.E., Ph.D., B.A., B.Sc., F.Inst.F., managing director of the National Industrial Fuel Efficiency Service; Dr. Llywelyn Roberts, M.D., M.R.C.P., D.P.H., medical officer of health, City of Sheffield ; and Professor M. W. Thring, M.A., F.Inst.P., F.Inst.F., M.I.Chem.E., Professor of Fuel Technology and Chemical Engineering, University of Sheffield.

Appointed until April 30, 1963, are: Stanley E. Cohen, Esq., C.C., F.R.S.H., chairman, City and Port of London Health Committee ; A. G. Dawtry, Esq., M.B.E., T.D., LL.B., town clerk of Westminster and honorary clerk to the Metropolitan Boroughs Standing Joint Committee ; L. Eastwood, Esq., C.R.S.I., M.A.P.H.I. chief public health inspector, Rotherham ; W. K. Hutchison, Esq., C.B.E., deputy chairman, Gas Board ; Alderman Mrs. R. F. Isley, chairman, Wolverhampton Health Committee ; W. E. Jones, Esq., O.B.E., past president of the National Union of Mineworkers, and member of the General Council of the Trades Union Congress ; J. L. Lewis, Esq., member of executive for Coal Preparation Plant of Manufacturers' Association and British Chemical Plant Manufacturers' Association ; Councillor Mrs. P. M. Mainwaring, member of Port Talbot Borough Council; and Dr. R. C. M. Pearson, M.D., M.R.C.P., D.P.H., medical officer of health, Newcastle upon Tyne.

European Technical Digests

Through its monthly publication the *European Technical Digests*, the European Productivity Agency of the Organisation for European Economic Co-operation, 2, Rue André-Pascal, Paris, provides a unique service at the disposal of industry in all countries and all continents. Every month over 1000 technical journals appearing in thirteen different countries and in eleven different languages are searched by qualified engineers for information on new processes, methods, apparatus or materials which could be readily employed in industry without large capital investment.

The purpose of the Digests is two-fold : firstly, to spread from one country to another, irrespective of language barriers, technical information and knowledge likely to increase productivity ; secondly, to crossfeed ideas from one industry to another.

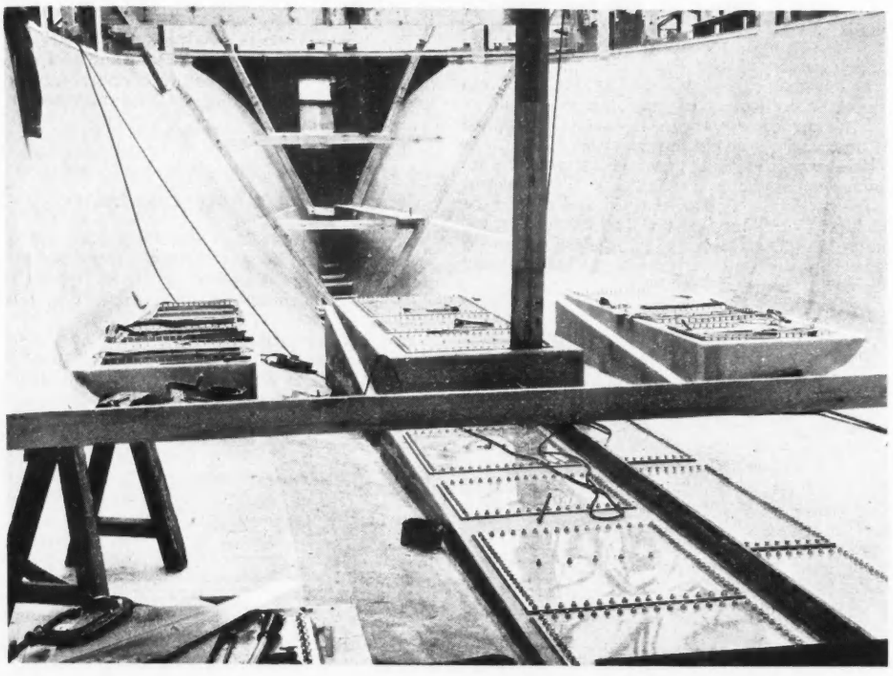
Although *European Technical Digests* also cover such sectors as glass, chemicals, leather, textiles and timber, they deal principally with all kinds of engineering and equipment, metallurgy and agricultural machinery ; moreover, much importance is attached to subjects of general interest, such as corrosion, materials handling, packaging, safety and management.

The success of this publication has induced a number of countries to publish translated versions so that, apart from the English edition, it now appears in German, Italian, Norwegian, Spanish, Turkish, Croat and Japanese and, on a selective basis, in Hebrew and Icelandic. Greece and the Netherlands produce translated title lists.

As a free readers' service, the European Productivity Agency supplies on request photocopies of the original articles on which the digests are based, and also additional information wherever possible. The price of a yearly subscription is £3 10s. ($12) ; of a six-monthly subscription (£1 15s.) ($6).

Large Moulded Resin-Glass Hull

THE hull of a 67ft long vessel recently completed at the Portsmouth works of Halmatic, Ltd., 10, Upper Berkeley Street, London, W.1, is claimed to be the largest one-piece resin-glass moulding yet manufactured. This design of vessel, known as the "Ocean Commander 67," has an overall length of 66ft 9½in, a beam of 16ft 4in and a draught of 4ft 3in. It is of composite form with heavily flared round bilge sections forward which are gradually developed to a full hard chine section which continues to a raked radiused transom. The full flare of the bow sections merges to a gentle reverse curve aft of amidships with a "slimming" concavity below the sheerline.



67ft long moulded resin-glass hull under construction

For the construction of the hull, which weighs some 11,500 lb, there was used a ply and veneer skin mould on a timber framework and this mould was made in three sections—port, starboard and transom—to facilitate its removal on completion of the hull. The hull is a "Deborine" moulding using Scott Bader "Crystic 189" polyester resin and "Fibreglass" 2 oz chopped strand mat, without filler, and it follows the firm's usual single shell "contact" or cold hand "lay-up" construction. The shell has a general thickness of $\frac{7}{16}$in to ½in comprising one layer of scrim and seven layers of 2 oz mat on the sides and eight layers on the bottom. This thickness is increased to about ⅝in by the addition of three extra layers of mat at the sheer and keel and further layers are added in the stem, chines, transom boundaries, shaft legs and rudder glands.

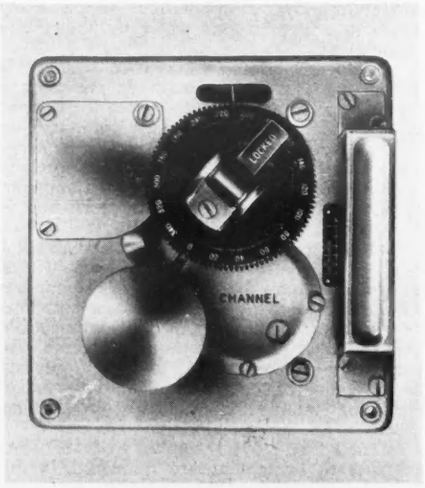
The framing, of the firm's hollow "top hat" design, comprises thin aluminium formers over which the moulding is formed; the aluminium "core" so provided is not designed to impart any strength to the main structure. This framing, spaced 9in from the bulkheads and webs and at about 15in centres, has a spread of 3in at the base, 1½in at the head and is 2¾in high. Its walls comprise three layers of 2 oz mat interspersed, on the head, by two glass roving tapes which run between the beam shelves.

In addition to the integral tanks and other structural parts of the hull, longitudinal stiffness is imparted by a 4in by ¾in marine ply beam shelf bonded into the shell between 3in by 3in angles of three layers of 2 oz mat. Two similar shelves are moulded in, one at about half freeboard height and the other at about datum water line, to provide for the attachment of accommodation flooring. A system of water and fuel tanks is integral with the hull, the vertical walls of the centre and wing fuel tanks embodying a ramped step to carry the engine mounting girders. These tanks can be clearly seen in the photograph we reproduce and it is stated that this engine girder foundation showed practically no deflection when tested to a loading of 4000 lb per foot run. The structure is further strengthened by the bonding of ¾in thick marine plywood bulkheads to the hull.

[Reply Card No. E3631]

Rotary Position Selector Unit

AN electrically-driven rotary position selector unit has been developed by the Plessey Company, Ltd., Ilford, Essex, in conjunction with the Ministry of Supply, for use with multi-channel transmitters and receivers. The device is stated to have other applications where it is required to rotate a shaft to preset positions by remote control with a high degree of accuracy. Available torque may be either 35 oz-in with an average operation time of six seconds, or 60 oz-in with an average operation time of ten seconds for full movement of the selector. In either case an accuracy of the order of six minutes of arc, and negligible creep after repeated operation, are claimed.



Setting controls and channel indicator of remotely-controlled position selector

Up to twelve desired angular settings are preset individually. The settings are independent of one another, and as a result of the accuracy of positioning may be separated by as little as twelve minutes of arc. The selector is driven by a permanent magnet motor, available for operation at from twelve to 48V, which is controlled by a relay. A single pair of leads connects the unit to whatever form of remote switching means is convenient for a particular application, such as a rotary wafer switch, telephone key switches or push buttons. To set the selector up, the control coarse adjustment dial (engraved at 5 deg. intervals) is unlocked and moved to the required setting for each channel as the motor is driven from channel to channel by means of the remote control switching. Fine adjustment is provided by a gear drive from a knob which can be removed and stowed away after setting up. The channel selected is shown in an indicating window on the front panel of the unit. A built-in switch can be incorporated for repeating the channel setting to the control position, and a further built-in switch may be used for operating other selector units in sequence, or for initiating some other action in the various positions of the selector.

When supplied as a plug-in unit with a thirty-seven way plug, the panel size is approximately 4in by 4in, but when necessary a 3¼in by 4⅜in panel can be supplied, the connections then being made by flying leads. The type number of the unit is 9008. Its operational temperature range is from −40 deg. to +70 deg. Cent., and the approximate weight is 2¼ lb.

(Reply Card No. E3632)

Milford Haven Launch Jetty

THE Milford Haven Conservancy Board is to build a launch jetty on the north shore of the Haven near Fort Hubberston. The works will comprise an approach road down the hillside and an approach jetty 300ft long leading to a jetty head. One arm of the "L"-shaped jetty head will form a 100ft long protective extension to the approach jetty; the seaward arm, lying parallel with the shore, will be 230ft long, and the two arms together will provide an adequate area of berthing protected from south westerly and south easterly seas on the inside, with unprotected berthing on the outside.

The approach jetty will consist of a concrete deck structure on precast piles with carriageway width of 10ft 6in between handrails. The pier head structure will consist of three reinforced concrete pontoon foundation units, which are to be built in a dry dock and towed to the site by tugs. When aligned in their proper positions, the pontoons will be allowed to settle on to the sea-bed where they will be temporarily steadied by four steel piles, in such a way that the top of the pontoon walls will be horizontal and at a level above that of low water neap tides. Precast concrete piles will then be driven to rock through slots already provided in the pontoons, to which the driven piles will be connected, so making a monolithic base to the structure. The road deck on the pier head will be 21ft wide and will be at a height of 6ft above maximum high water. It will be supported by precast concrete diaphragm walls erected on the top of the foundation units. A steel-sheet-piling wall will then be fixed between the deck and the top of the foundation units along the seaward side of the two arms of the pier head. This sheet piling will complete the protection of the inside of the jetty against wind and sea.

The contract for constructing the works has been let to Peter Lind and Co., Ltd. The consulting engineers are Messrs. Posford, Pavry and Partners. The work is expected to take about a year to complete at an estimated cost of about £150,000.

SHORTER REPORTS *(Continued)*

Beilby Medal and Prize

AT intervals of one or more years since 1930, awards have been made to British scientific investigators by the administrators of the Sir George Beilby Memorial Fund, representing the Royal Institute of Chemistry, the Society of Chemical Industry, and the Institute of Metals. Sir George Beilby had been President of each of these three bodies, and they were joint sponsors of the appeal for subscriptions whereby the fund was raised as a memorial to Sir George after his death in 1925.

The awards are made to British scientific investigators in recognition of original work of exceptional merit, carried out continuously over a period of years, and relating to any of the fields in which Sir George Beilby was specially interested ; namely, chemical engineering, fuel technology or metallurgy, in their modern interpretations. The awards are intended as an encouragement to younger men and women (preferably under the age of 40) who have done distinguished work of practical significance in any of the fields mentioned. Two awards, each of 150 guineas, were made in 1958, and it was then agreed that no further award should be made before 1960.

It has now been decided that henceforth each award shall consist of a gold medal as well as a substantial sum of money, and shall be known as " The Beilby Medal and Prize." Such an award, specified as being " For Advancement in Science and Practice," will be offered at intervals of two years. More than one award may be made on the same occasion if there are several candidates of outstanding merit.

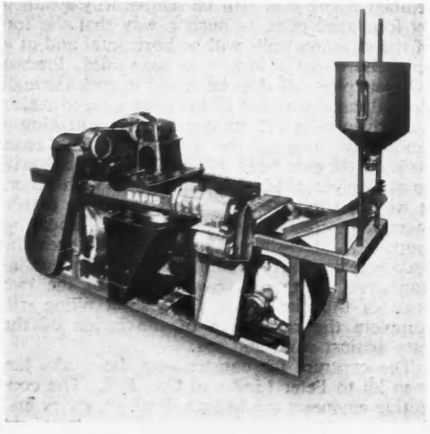
Outstanding work of the type indicated may be brought to the notice of the administrators, either by persons who wish to recommend the candidate, or by the candidate himself.

This should be done by letter, accompanied by nine copies of a short statement on the candidate's career (date of birth, education and experience, degrees and other qualifications, special awards, &c., with dates), and a list of titles, with references, of papers or other works published by the candidate, independently or jointly. Photographic copies of these documents are acceptable. One reprint of each published paper should also be sent where copies are available.

The letter should be sent, not later than December 31, 1960, to the Convenor of the Administrators, Sir George Beilby Memorial Fund, The Royal Institute of Chemistry, 30, Russell Square, London, W.C.1.

Magnetic Mineral Separator

A HIGH intensity mineral separator of single disc design has been introduced by Rapid Magnetic, Ltd., Lombard Street, Birmingham, 12, for treating granular free-flowing minerals such as garnet, monazite, ilmenite, wolfram, columbo-tantalite, &c. This machine, to be seen in the illustration, incorporates a magnetic scalper prior to the disc, and this scalper removes highly magnetic minerals such as magnetite, ferro-silicon and other iron oxides, so preventing agglomeration at disc discharge.



Single disc separator with magnetic scalper for removing highly magnetic materials

By mechanical adjustment of the disc and rheostatic control of magnet current, a further two magnetic minerals are separately recovered at one passing and discharged either side of the separator belt. Clean non-magnetic materials are discharged at the conveyor head. The machine is fed by gravity from a hopper, and if required a vibratory unit can be supplied for feeding the material. The capacity of the separator is dependent on characteristics of the material and degree of separation required.

[Reply Card No. E3642]

Surface Treatments for Aluminium

THERE has been announced by the Pyrene Company, Ltd., Great West Road, Brentford, Middlesex, a range of treatments for aluminium and its alloys which are claimed to improve its appearance, corrosion resistance, or paint retention.

The " Bonderising " techniques represent an economical low temperature method of coating aluminium, converting the aluminium surface into a thin amorphous oxide-chromate coating which is integral with the metal itself.

" *Bonderite* " 710.—" Bonderite " 710 coatings are of a well-defined golden colour, though variations in tone may occur according to the different alloys used.

The applications and potentialities of this process are extremely diverse. It will treat with equal efficiency such varied objects as small aluminium parts and continuous strip. " Bonderising " is in use on strip lines in this country for the treatment of aluminium strip at over 60ft per minute. Processing times are exceptionally low, offering fast and economic production techniques.

" Bonderised " aluminium can, if necessary, be formed after painting. The amorphous coating, itself inseparable from the metal surface, tightly bonds the paint so that complex forming operations can be performed without impairing paint adhesion.

" *Bonderite* " 701.—The " Bonderite " 701 process converts the aluminium surface into an amorphous oxide-chromate coating of a green colour which is integral with the metal and is light-fast. The coating, in its own right, offers excellent corrosion protection to aluminium and aluminium alloys. " Bonderite " 701 has many architectural applications where durability and colour count.

" *Bonderite* " 740.—" Bonderite " 740 is another oxide-chromate treatment providing a coating which is both an ideal base for organic finishes, and a corrosion resistant film in its own right. It can be applied by immersion, by spray or in a continuous strip line. It has been specially developed for treating aluminium and aluminium alloys in mixed production with steel, and is virtually equally effective with both.

" *Aluma Etch* " 391.—" Aluma Etch " 391 is a scale free, controlled alkaline etchant for uniformly etching the surface of aluminium in an immersion bath. Unlike etching solutions in which dissolved aluminium reacts with caustic soda to form insoluble sodium aluminate, the special formulation of " Aluma Etch " prevents the conversion of sodium aluminate into sludge. The use of " Aluma Etch " therefore produces no suspension and no precipitate.

" Aluma Etch " 391 is applied by immersion: the parts to be treated are immersed in the hot solution for a predetermined time to remove soil and to produce the required degree of etch. On removal from the bath, the parts are merely cold water rinsed in a bath sufficiently overflowed to prevent contamination. Once the desired degree of etch has been established for a particular alloy, operations may be easily controlled to produce the required etch, uniform and evenly diffused, no matter what the size of surface area to be covered.

The etching process removes surface markings due to working, handling, damage and so forth, and is usually performed before "Bonderising" or anodising if the finished appearance is important.

[Reply Card No. E3643]

Stress Analysis Committee

A " JOINT BRITISH COMMITTEE FOR STRESS ANALYSIS " has been set up to represent the interests and participation of Great Britain at international conferences in the field of stress analysis.

A " Permanent Committee," membership of which is open to all west European countries is to arrange international conferences at four-year intervals. Such conferences will normally be phased with the International Congresses on Applied Mechanics. The objectives of the joint British committee for stress analysis will be to act in the collective interest of the constituent bodies : (*a*) by maintaining liaison with the permanent committee for European or international conferences on stress analysis, and (*b*) by maintaining liaison with overseas societies and institutions concerned with stress analysis.

The joint British committee consists of representatives appointed by The Royal Aeronautical Society, the Institution of Civil Engineers, the Institution of Electrical Engineers, the Institute of Marine Engineers, the Institution of Mechanical Engineers, the Royal Institution of Naval Architects, the Institute of Physics and the Physical Society, the Institution of Structural Engineers and the Institute of Welding. Mr. A. F. C. Brown of the National Physical Laboratory, and the representative of the Institution of Mechanical Engineers, has been elected the first chairman of the committee, and the Institution of Mechanical Engineers provides the Secretariat for the committee.

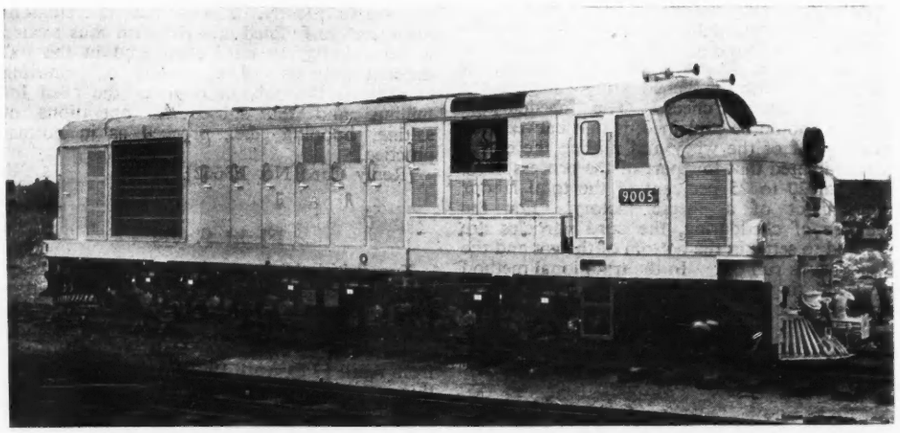
Symposium on the Protection of Gas Plant

A JOINT Symposium is to be held by The Institution of Gas Engineers and the Society of Chemical Industry on " The Protection of Gas Plant and Equipment from Corrosion " on Thursday and Friday, September 22 and 23, at the College of Advanced Technology, Gosta Green, Birmingham 4. On Thursday morning Dr. P. F. R. Venables, the Principal of the College, will give the opening address and then with Mr. H. S. Cheetham, President of The Institution of Gas Engineers, in the chair two papers will be presented, " Fundamentals of Corrosion and Protection," by Dr. T. P. Hoar, and " Organic Protective Coatings," by A. T. S. Rudram. In the afternoon, with Mr. L. Kenworthy in the chair, Dr. J. C. Hudson will give his paper " The Protection of Structural Steel Against Corrosion," followed by " The Corrosion of Cast Iron in the Gas Industry," by H. H. Collins. Mr. G. Le B. Diamond, Chairman of the West Midlands Gas Board, will be in the chair on Friday morning when the following papers will be read, " Principles and Applications of Cathodic Protection," by K. A. Spencer, and " Protection of Gas Service Pipes and Fittings," by A. D. L. Copp, W. G. Gooderham and E. Manners. At the final session on Friday afternoon, Mr. R. S. Johnson, Chairman of the East Midlands Gas Board, will preside and the paper " Corrosion and the Gas Consumer," by F. C. Moody and C. H. Purkis, will be read, followed by " Sprayed Metal Coatings in the Gas Industry," by R. E. Mansford.

Diesel Locomotives for East Africa

TEN main line diesel-electric locomotives are being supplied to the East African Railways and Harbours Administration by the English Electric Company, Ltd., and are being built at the Darlington works of Robert Stephenson and Hawthorns, Ltd., a member of the English Electric Group. Power equipment of this series is similar to that of the fifteen C_0-C_0 locomotives for the Sudan Railways described in our February 19 issue, page 300 ; the engine being the English Electric 12CSVT pressure-charged unit with charge-air cooling, but the wheel arrangement is $1C_0$-C_01, the weight of 97½ tons being distributed as 12·8 tons on the driving and 10·3 tons on the guiding axles.

A calibrated adjustment on the engine enables the output to be set according to the conditions on the section of line where the locomotive is to operate. For regular service on the Mombasa-Nairobi route, where the altitude does not exceed 5500ft above sea level, the engine may be set to 1840 h.p., but for service at altitudes up to 7800ft the setting is 1800 h.p., and for working between Nairobi and Kampala it would be 1775 h.p. on account of the altitudes of over 9000ft which are met with there. Further special provisions in the design for the requirements of the East African Railways are convertibility from metre gauge, as built, to 3ft 6in gauge, and equipment for working both air-braked and vacuum-braked stock until the changeover to vacuum braking has been made on the railways.



1840 h.p. diesel-electric locomotive with dynamic braking for the East African Railways and Harbours

During an inspection of the locomotives under construction at Darlington on August 18, attention was drawn to the one-piece cast steel bogie frame, giving maximum accessibility to the suspension, and the three-point support of the body on each bogie. This consists of a pivot seating in a fixed bolster near the front of the frame, and two sprung side bearers towards the rear. The pivot has a rubber insert to give resilience in all directions at this point. Equalising beams interconnect all axle suspensions and are carried through to the bissel truck, which has a centre pivot in a spring-controlled sliding bolster. Initial compression of the springs restrains hunting of the truck, and when side movement of the bolster takes place the increased controlling force assists the guiding of the main bogie on curves. A spring side-control device is fitted between the bogies for reducing flange forces.

The absence of a central bolster in the main bogie frame enables all motors in a bogie to face in the same direction, and this direction is reversed as between the two bogies for automatic compensation of weight transfer effects. This characteristic combines with the full equalisation, the three-point weight distribution and appropriate spacing of driving and carrying axles, to produce a bogie which is claimed to be inherently opposed to loss of adhesion from this cause. The designers consider that where high tractive efforts have to be developed, the use of carrying axles in conjunction with driving axles reduces track stress for a given axle load and allows higher adhesive weights per axle to be used.

The locomotive is equipped for dynamic braking, using force-ventilated resistor units similar to those in the Sudan design referred to above, but adapted for mounting in the sides of the bonnet superstructure. One of the units is seen to the left of the cab door in the accompanying illustration. All louvres in the body sides are designed to eject rain or sand before entering the filters. Some 28,000 cubic feet per minute of air is filtered for the engine and generator compartments, and 5000 or 6000 cubic feet per minute are extracted continuously by a motor-driven fan for engine-room cooling. The locomotive is normally driven with the cab leading, from a right-hand driving position, but a second position is provided on the left and angled to to facilitate observation through a rear window when running in reverse. Principal controls at the two positions are mechanically interlinked and there is a dead man's treadle at each. If the driver changes to the left-hand seat to make a tablet exchange, for example, he can assume control immediately at this position.

An addition to the cab equipment compared with the Sudan locomotives is an Oerlikon vigilance system, manufactured in this country by Davies and Metcalfe, Ltd. This provides for a bell warning being sounded if no movement of the main controls has been made for a preset distance, such as 1½ miles. The warning is acknowledged, and further action arrested, by pressing the vigilance button on either desk, but if no action is taken by the driver, power is cut off and an emergency brake application is made. The warning may also be anticipated and overridden by periodical operation of the vigilance buttons.

The locomotive is controlled by continuous adjustment of the engine speed through a compressed air system, in conjunction with automatic adjustment of the main generator excitation by a load regulator driven by an oil-operated servo motor. In the event of sudden, large movements of the controller a small delay in the response of the engine is inherent in the system. This facilitates starting with light loads, but if the controller movement has been brusque enough for wheelslip to have been set up, the engine speed is automatically reduced until slipping stops, and a warning is sounded. Other cab facilities include windscreen washing equipment in addition to wipers.

Construction of these locomotives at the Darlington works of Robert Stephenson and Hawthorns, Ltd., is taking place alongside numerous type 4, 2000 h.p. diesel-electric locomotives for British Railways, a 750 h.p. industrial diesel-electric design for South Africa, battery electric locomotives for the National Coal Board, and British Railways 204 h.p. diesel-mechanical shunters.

Graphite Cartridge Condensers

A 90 square foot graphite cartridge condenser

OUR illustration shows a " Delanium " graphite cartridge condenser, having an exchange surface area of 90 square feet, which is the largest of a new range of condensers, the smallest being of 4 square feet, added to its graphite heat exchange equipment by The Chemical Engineering Division of Powell Duffryn Carbon Products, Ltd. It has been specifically designed to solve condensing problems involving corrosive vapours, and the graphite element is equipped with through holes along the major axes down which the condensing vapour passes. The service fluid passes in counter-flow through the annular space between the steel jacket and the slotted outer surface of the cartridge. Should service fluids other than water be employed the steel jacket may be lined with suitable inert materials. Carbon inlet and outlet heads complete the assembly and strong mounting lugs enable the unit to be easily and quickly installed. The new units are compact, 1 square foot of graphite heat exchange surface being equivalent to 3 to 4 square feet of glass surface, and have been extensively tested for use in pharmaceutical applications.

[Reply Card No. E3652]

Industrial Turntable in Paper Mill

WHEN J. W. Marshall and Co., Ltd., decided to increase considerably its paper production a bottle-neck occurred at the cutting stage where a sheet cutter is fed from an adjustable reel frame carrying up to twelve rolls of paper according to grade. The problem was the reloading of these frames, an operation which took about two hours so that, since it took two to three hours to exhaust the frame, the cutting machine was standing idle for periods totalling nearly half of its working day. As an alternative to introducing a night-shift or a second cutting machine, it was decided to install a turntable capable of carrying two reel frames. This unit was built by the Bolton Turntable Company, Ltd., and it has a diameter of 15ft, is capable of taking a load of 10 tons and may be rotated, when fully loaded, by one man. Now it is incorporated in the flow line, one frame feeds the cutting machine while the other is being loaded; thus the cutting machine is operated non-stop and it is understood that in any period of twenty-four hours only fourteen hours are now worked instead of twenty-one hours to give the same level of production, thus representing a 50 per cent. increase.

[Reply Card No. E5653]

SHORTER REPORTS *(Continued)*

Automatic Weight Control

Two equipments for use in conjunction with load cells for providing a control function when a preset weight is reached have been standardised by Elcontrol, Ltd., Wilbury Way, Hitchin, Herts. They are designed for dealing with industrial loads of the order of 20 lb up to 2000 tons and are used in conjunction with one, two or three load cells on which the load is supported, or from which it may be suspended. Load cells are supplied to meet individual specifications as required by the application and

Typical load cell for use with automatic weight control system

physical arrangement of the installation or plant concerned. A normal load cell for these applications, shown in an accompanying illustration, consists of a high-tensile steel billet, generally cylindrical and drilled through the centre, to which are cemented a number of fine wire strain gauges. The gauges are connected in a bridge circuit which is balanced under no-load conditions. On application of load, one or more of the gauges will be changed in length under compression or tension and their electrical resistance will vary accordingly. The bridge will thus become electrically unbalanced and the degree of out-of-balance is detected and made use of in the control unit.

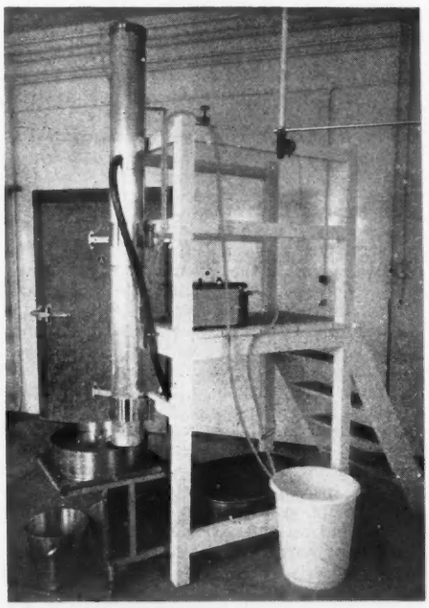
A relay in the unit integrates the output from the cells. The integrated output voltage is monitored and when it reaches a value corresponding to the selected operating weight, the relay is operated and actuates the control mechanism (such as a conveyor motor, chute gate, automatic valve, diversion plough, and so on). The two control units now standardised are known as LC4 and LC5 (illustrated). In both patterns the trip point, zero and differential, are adjustable. The LC5 also provides an indication of the percentage deviation of the load from the set trip value, and this may be presented on one or more remote deviation indicators. The trip point in both units is adjustable by means of a ten-turn potentiometer. A further control sets the point at which the trip relay de-energises and can be adjusted from a minimum differential to 90 per cent of rated load, enabling the units to be used for high/low weight or quantity control.

[Reply Card No. E3661]

Weight controller opened, showing connection compartment separate from casing housing the electronic chassis and components

Machine for "Cheddaring"

An interesting example of the mechanisation of a traditional hand operation was demonstrated to us recently at the National Institute for Research in Dairying, Shinfield, Berks. It is concerned with the "cheddaring" stage in the making of Cheddar cheese. The "cheddaring" stage, it should be explained, is that between the running off of the whey and milling the curd; it is estimated that this part of the process takes up from 20 to 25 per cent of the total labour requirement of a cheese factory. For the purpose of cheddaring, the curd particles are allowed to settle in the bottom of the vat and the free whey is run off. In the traditional method of cheddaring, the resultant mass of curd is cut into small blocks which, at regular intervals



Cutting blades at the bottom of the vertical tube remove the curd at a fixed rate

over a period of 1½ hours to 2½ hours, are turned and stacked, one on top of another, into piles. During this process, the curd particles fuse into a continuous mass and the blocks of curd become deformed under the weight of the piles and spread sideways.

The operations of turning and piling the curd are carried out by hand and demand a good deal of physical effort. In considering the mechanisation problem, the principal objectives kept in mind were the simplification of the cheddaring process, reducing the amount of effort involved and replacing the existing batch process by a continuous one. These objectives, it is claimed, have been met by a simple piece of machinery which has been developed at the National Institute for Research in Dairying, in conjunction with the National Research Development Corporation, 1, Tilney Street, London, W.1. The apparatus is illustrated above.

A column of curd is contained within the tall vertical tube which has an increasing diameter from top to bottom; cutting blades situated at the bottom of the tube support the column and rotate to remove curd at a fixed rate. Meanwhile a steady supply of curds and whey is maintained to the top of the tube to keep it full. The whey drains off through perforations in the wall of the tube and the curd remains to build up the column. In this way a continuously moving column of curd is produced and each particle of curd, as it travels down through the tube, is subjected to increasing pressure by the weight of curd above it, and is allowed to spread sideways because of the increasing diameter of the tube. The rate at which the curd travels down the column is such that acidity is given time to develop sufficiently. The cheddaring conditions are therefore fulfilled and the curd thus treated is very similar to curd cheddared in the traditional manner. The method of removing curd from the column obviates the need for milling, and the subsequent operations of salting, hooping, &c., proceed as in normal practice.

[Reply Card No. E3662]

Fluid Seals

The British Hydromechanics Research Association is organising an international meeting for the discussion of technical advances which have been made in fluid sealing. This meeting is to be held at Grosvenor Hall, Ashford, Kent, from April 17 to April 19, 1961, and the association states that it will welcome all fundamental contributions to the theory of sealing or a related topic. The meetings are to be organised under four main headings—liquid seals, gas seals, sealing materials and miscellaneous seals.

All enquiries in connection with this meeting should be addressed to the Information Officer, British Hydromechanics Research Association, South Road, Temple Fields, Harlow, Essex.

Launches and Trial Trips

Ellenga, oil tanker, built at Wallsend by Swan, Hunter and Wigham Richardson, Ltd.: for the British Steam Navigation Company, Ltd., length between perpendiculars 660ft, breadth moulded 90ft, depth moulded 48ft, deadweight 37,140 tons on 36ft 4½in draught, loaded service speed 16 knots; thirty-three cargo oil tanks, cathodic protection, one main cargo pump room, four 1350 tons per hour centrifugal pumps and two 330 tons per hour stripping pumps; two 750kW turbine-driven alternators, one 200kW diesel-driven alternator; one set of Wallsend Slipway double-reduction geared turbines, 16,000 s.h.p. at 105 propeller r.p.m., steam supplied at 600 lb per square inch and 850 deg. Fah. by Babcock and Wilcox selectable superheat boilers. Trial, May 27.

Tapon, fruit carrier; built by the Chantiers Reunis Loire-Normandie for the Compagnie Fraissinet (Marseilles); length between perpendiculars 349ft 3in, breadth moulded 52ft 5in, depth to upper deck 36ft 9in, draught 19ft 8in, deadweight 1400 tons, service speed 17·5 knots; four 220kW diesel-driven generators; two 3840 h.p. S.E.M.T.-Pielstick diesel engines driving a single propeller through Vulcan double-reduction gearing.

Centaure, oil tanker; built by the Chantiers Navals de la Ciotat for the Compagnie des Messageries Maritimes; length between perpendiculars 712ft, breadth moulded 99ft 4in, depth 54ft 10in, draught loaded 40ft 6in, deadweight 51,500 tons, service speed 17·4 knots; one set of C.E.M.-Parsons turbines, 20,200 s.h.p. at 108 propeller r.p.m., two Foster Wheeler boilers supplying steam at 600 lb per square inch and 850 deg. Fah. Trial, May.

Kanga, fruit carrier; built by the Forges et Chantiers de la Mediterranée (Le Havre) for the Compagnie Maritime des Chargeurs Réunis; length between perpendiculars 336ft, breadth moulded 51ft 9in, depth to shelter deck 33ft 1in, deadweight 3100 tons on 21ft draught; five holds, ten 5-ton derricks, three 280kW diesel-driven generators; one supercharged six-cylinder Sulzer diesel engine, 5400 h.p. at 125 r.p.m. Trial, May.

INDUSTRIAL NEWS

Industrial Relations and the T.U.C.

The general council of the Trades Union Congress at its annual congress held at Blackpool last year undertook to look into and report on the broad problem of disputes, workshop representation and related matters. An interim report prepared by the trade union side of the National Joint Advisory Council which conducted the inquiry, forms an important part of the general council's report to the ninety-second annual congress of the T.U.C. to be held this year at Douglas from September 5 to 9.

Questionnaires were sent out in November last year seeking information about the cost in dispute pay of stoppages in the years 1956–59 ; details of official and unofficial strikes in 1958 and 1959; and details of cases in those two years where the employment of a union's members was affected through the stoppage of work of members of another union. Replies to the questionnaires were received from 147 unions with 7,510,000 members. Altogether 445 reports of strikes were received, although these did not relate to 445 different strikes as in some cases several unions reported on the same strike. The replies have been analysed, the report states, and the principal causes of the strikes reported show that 32 per cent concerned money, two-thirds of this figure relating to wage rates and one-third to bonus payments. These strikes included cases where workers claimed higher amounts and cases where they resisted employers' attempts to impose reductions. Dismissals accounted for 29 per cent, of which 20 per cent were dismissals of stewards or of members on disciplinary charges, and 9 per cent arose from disputes over redundancy arrangements. About 6 per cent each had to do with recognition, non-unionism, breaking of agreements or awards by employers, changes of work systems, and demarcation or dilution. Of the remainder, the report adds, about half were caused by complaints about conditions in which work was expected to be carried on, and by complaints about supervisors.

In its remarks on unofficial strikes, the report points out that in about half the cases reported to the general council where strikes began without official sanction, the unions paid dispute benefit. The other half, the report states, were less spontaneous and included instances where strike action was taken or prolonged contrary to general policy and specific advice, and, in such cases, the report recommends that unions should take some form of disciplinary action against the members concerned. Dealing with joint organisations of stewards, the report says that although each union can allocate a sphere of responsibility for its own stewards, no union is individually in a position to bring within its rules the joint committee of stewards from several unions or the officers of such joint bodies. Some joint arrangements between stewards have been harmful, the report continues. Where decisions about a programme of demands and priorities have been constitutionally taken in a union it is wrong for stewards in that union to set them aside and to follow another path through a joint stewards' committee on the excuse that this other path is " official " or acceptable to one of the other unions. Cases have been reported to the general council, the report states, where joint stewards' bodies have concluded agreements inconsistent with union policies : in these cases the joint character of the stewards' body has been used as an excuse for not referring the matters to the proper channels in the unions concerned.

The high level of post-war employment has greatly increased the opportunities of stewards to give service to membership, the report continues. But no more than any other union representatives, it adds, are stewards entitled to act contrary to union rules or agreements. Unions should be more vigilant, the report advises, and if, after a warning, a steward repeats actions which are contrary to rules or agreements his credentials should be withdrawn.

Recruitment and Training

A three-day conference organised by the Federation of British Industries on recruitment and training policy in small firms is to be opened by Sir Norman Kipping at Buxton on September 26. This is the first national conference of its kind to be held by British industry, and is intended for top executives of firms employing less than 1000 people. Its purpose, the Federation says, is to examine the recruitment and training problems faced by firms of that size and to find possible solutions.

The idea was inspired, the Federation states, by a growing realisation amongst its members that the 23,000 small United Kingdom firms, which between them employ 39 per cent of the industrial labour force, must step-up their drive for technological progress if they are to succeed against growing competition from overseas. It is felt, the Federation says, that those firms which fail to ensure technical and executive managerial continuity and planned expansion may face grave difficulties in the future.

Training Boys in Industry

A booklet has been published this week by the Industrial Training Council drawing attention to the problem of training boys other than those trained by apprenticeship. Apart from those taken in as apprentices, the majority of boys entering industry at present receive no systematic training, the Council says, and in considering what the training needs of these young people are, the Council has reached the conclusion that systematic training is essential for all boys entering industry in whatever capacity they are immediately employed.

While such training may take a number of forms the two essential elements in it, the Council feels, are planned practical training in the workplace and further education, although, it is pointed out, neither of these elements can in the long term be sufficient in itself. The practical training, the Council suggests, should consist of planned learning by practical experience supplemented by instruction, either on the shop floor or where appropriate in a special training centre at the workplace. For some " semi-skilled " jobs there will be a specific need for vocational further education as a complement to the practical training, whilst for other " semi-skilled " jobs and for " unskilled " jobs it is unlikely that such vocational further education will be an essential adjunct to training. The Council also considers that there will in the future be more and more need for tranferences of workpeople from one job to another and for their retraining, and this will require a mental flexibility which can only be developed by further education after the end of full-time schooling. The Council stresses the importance of relating general further education to the experience the boy gets in his employment rather than making it purely academic, but warns against making it narrowly vocational. This will require close co-operation between industry and the technical colleges, and the Council therefore considers that industry would benefit by extending day-release facilities, or their equivalent, for further education to all boys up to the age of eighteen. The immediate loss in their production, the Council feels, will be amply repaid in later years.

The second section of the Council's booklet—" Training Boys in Industry : The Non-Apprentice "—gives examples of systematic training arrangements on the lines suggested which are already in operation in fifteen companies and one group of companies. Copies of the booklet are to be sent out to all branches of industry, urging the need to reconsider training arrangements for non-apprentices against an analysis of the broad range of skills which employees are likely to use in future years and the possibility that they may be redeployed to new jobs requiring new skills.

Rural Industries' Exports

The Rural Industries Bureau, which is entrusted by the Government to provide technical advice and assistance to country workshops, has published its annual report. During the year under review a far more intensive advisory service on selling abroad became possible following the appointment of an export officer, says the report, some forty counties in England and Wales having been visited by the officer, and a wide variety of problems advised upon. The problem has often been to guide a firm from thinking in terms of home markets only to tackling export outlets. A great deal of advice has been given on export procedure, the report states, including shipping documentation, special invoicing and conditions of payment, exchange control and foreign customs duties. Once these initial difficulties have been cleared it has been possible to recommend export outlets.

In a statement accompanying the annual report, Sir Basil Mayhew, chairman of the trustees of the Rural Industries Bureau, says that the variety and extent to which small production industries in country districts are contributing to the export trade has been an encouraging feature during the year. The Bureau has now produced a small book entitled *Export Made Easy*, explaining in very simple form the procedure to be adopted by a small producer anxious to get into the export field.

PERSONAL AND BUSINESS

Appointments

MR. FRANK WILSON has been appointed public relations officer to Whitlock Bros., Ltd.

MR. CHARLES DODD has been appointed press officer to the Cementation Group of Companies.

MR. J. ALCOCK has been appointed to the board of directors of Midgley and Sutcliffe, Ltd.

MR. C. F. PAGNAMENTA, secretary of Guest Keen Iron and Steel Company, Ltd., has been elected a director.

MR. JAMES A. PETRIE, Jr., has been appointed assistant to the President of Kellogg International Corporation in London.

MR. J. BANKS, M.I.E.E., has been appointed chief engineer of the power cables division of British Insulated Callender's Cables, Ltd.

COLONEL S. J. COX, M.I.Mech.E., has been appointed vice principal of the Chelsea College of Aeronautical and Automobile Engineering.

MASSEY-FERGUSON, LTD. has announced that Mr. J. H. Taylor has been appointed general factory manager of its Banner Lane tractor plant in Coventry.

MR. G. H. MARCHANT, general manager, has been elected to the board of directors of Fafnir Bearing Company, Ltd. His title will now be director and general manager.

MR. WILFRID J. FRY, a director of Solartron Research and Development, Ltd., has been appointed sales director and commercial manager of Solartron-John Brown Automation, Ltd.

MR. G. A. DWYER arrived in India on August 22 to take up an appointment as representative in India and Ceylon for the Marconi International Marine Communication Company, Ltd.

THE MINISTRY OF TRANSPORT states that Colonel Donald Cameron, of Lochiel, has been re-appointed to be a part-time member of the British Transport Commission until August 31, 1961.

ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., has appointed Dr. David Conrad Milner as editor of the new A.E.I. technical journal *A.E.I. Engineering*. He will take up his post at the end of the year.

MR. WILLIAM J. DIXON, chairman and managing director of James Walker and Co., Ltd., recently celebrated sixty years' unbroken service with the company.

THE BRITISH IRON AND STEEL RESEARCH ASSOCIATION announces that Mr. J. F. Stanners has succeeded Dr. J. C. Hudson, who has retired, as head of corrosion research in the chemistry department. Mr. E. E. White has been appointed head of the corrosion advice bureau.

SIMMONDS AEROCESSORIES, Ltd., announces the following appointments in the filtration division: Mr. N. J. Cubitt, assistant sales manager for "Fram" filters for the motor vehicle and engine manufacturing industries; Mr. E. K. Martin, assistant sales manager for industrial filters.

MR. EDWIN BADEN has been appointed chairman of Matthew Hall and Co., Ltd., and has resigned as managing director. Mr. R. R. Baden has been appointed deputy chairman, and Mr. P. D. Doulton and Mr. S. Kindler have been appointed managing directors. Mr. R. M. Speir has been appointed a director.

MR. L. A. LLOYD has been appointed spares and service manager of the contractors' plant department (southern area) of Thos. W. Ward, Ltd., and will be based at Titan Works, Grays, Essex. Inquiries for spare parts for Fowler Marshall tractors should be directed to that address (telephone, Grays Thurrock 4806 and 4764).

MR. AUSTIN GEOFFREY SMITH, A.F.R.Ae.S., at present Professor of Aircraft Propulsion at the College of Aeronautics, Cranfield, has been elected the first holder of the Hives Chair of Thermodynamics, endowed by Rolls-Royce, Ltd., in the University of Nottingham. Professor Smith will be the Head of the Department of Mechanical Engineering in succession to Professor J. A. Pope.

MR. R. W. STUART MITCHELL, A.M.I.C.E., M.I.Mech.E., has relinquished his appointment as group chief engineer to Associated British Engineering, Ltd., in order to accept the new chair of gas turbine technology at the Technological University of Delft, Holland. He will retain his connection with Associated British Engineering, Ltd., as technical adviser to the Group for a period of two years in the first instance.

MR. E. H. BLACK, chief engineer of the Midlands division of the Marco Conveyor and Engineering Company, Ltd., has now been appointed chief engineer to the company. He will be based at Rowin Works, Leytonstone, instead of in Birmingham as hitherto.

WOODALL-DUCKHAM CONSTRUCTION COMPANY, Ltd., states that in order to provide for the evolution of the board, the following changes and additions have been made: Mr. J. Simpson has been designated deputy chairman (group); Mr. E. N. Wenborn has been appointed vice chairman; Mr. C. D. Muntz has been appointed a joint managing director; Mr. A. F. Cottrell has been appointed director-in-charge, operating department; Mr. H. E. Dyble, director-in-charge, construction department, and Mr. R. O. Richards, director-in-charge, design and development department.

GUEST, KEEN AND NETTLEFOLDS, Ltd., announces that, with the object of providing more direct and personal assistance to the group chairman, Mr. W. A. Nicol, director and group secretary, and Mr. W. W. Fea, director and group chief accountant, are relinquishing their offices of group secretary and group chief accountant and have been appointed administrative director and financial director respectively. Mr. J. F. Howard, assistant secretary, has been appointed group secretary and Mr. F. C. Rowbottom, assistant chief accountant, has been appointed group chief accountant.

Business Announcements

BRITISH INSULATED CALLENDER'S CABLES, Ltd., announces that the telephone number of its Chessington Depot is now Lower Hook 3366/7/8.

JAMES HOWDEN AND CO. AUSTRALIA PTY., Ltd., states that its address for all communications has now been changed to 453, Elizabeth Street, Melbourne, C.1, Australia.

NATIONAL SOCIETY FOR CLEAN AIR has changed its address from Palace Chambers, Bridge Street, S.W.1, to Field House, Breams Buildings, London, E.C.4 (telephone, Chancery 5040).

MR. T. JOLLY, joint managing director of Guest Keen Iron and Steel Company, Ltd., will retire from his office and from the board of directors on January 1, 1961, for health reasons.

WINSTON ELECTRONICS, Ltd., Shepperton, Middlesex, has appointed Hird-Brown, Ltd., 244, Marsland Road, Sale, Cheshire, as sales distributor to Yorkshire, Lancashire, Cheshire and North Wales.

JOHN WILEY AND SONS, Ltd., Gordon House, Greencoat Place, London, S.W.1 (telephone, Victoria 0143), has been established in this country by John Wiley and Sons Inc. of New York. The company will begin to operate on August 29.

DRABBLE AND SANDERSON, Ltd., Sheffield, has been appointed sole agent in the United Kingdom for the sale of carbide tipped circular saws manufactured by the American Saw and Tool Company of Louisville, U.S.A.

THE PYRENE COMPANY, Ltd., 9, Grosvenor Gardens, London, S.W.1, has taken over from the Ministry of Aviation a factory at Melingriffith, near Cardiff. The factory has a floor area of approximately 90,000 square feet.

HELLERMANN, Ltd., Phosphate Protection Division, Crawley, Sussex, announces that it has been granted D.I.ARM. (Inspectorate of Armaments.) and I.F.V. (Inspectorate of Fighting Vehicles.) approvals for its phosphating solutions.

SIEBE, GORMAN AND CO., Ltd., has announced that its Mark 4 compressed air breathing apparatus has been granted the approval of Her Majesty's Chief Inspector of Factories under the Chemical Works Regulations, 1922.

T. AND T. WORKS, Ltd., Billesdon, Leicester, has been appointed sole concessionnaire for the manufacture and distribution in the United Kingdom and most Commonwealth territories of the American "Chainveyor" overhead monorail conveyor system.

THE ENGLISH ELECTRIC COMPANY, Ltd., announces that a new division is to be formed to combine all aspects of the company's hydro-electrical engineering at its Netherton Works, near Liverpool. From September 1, the new hydro-electric division will be responsible for the commercial, engineering and manufacturing operations connected with hydro-electric installations, including the design and manufacture of water turbines and alternators, large valves and other ancillary equipment. Manager of the new division will be Mr. J. Gavin Warnock.

GRESHAM DEVELOPMENTS, Ltd., Twickenham Road, Hanworth, Middlesex, and LION ELECTRONIC DEVELOPMENTS, Ltd., Hanworth Trading Estate, Feltham, Middlesex, have been amalgamated to form a new company, Gresham-Lion Electronics, Ltd., Gresham House, Twickenham Road, Hanworth, Middlesex (telephone, Feltham 2271). The directors are Mr. John P. Coleman, M.I.E.E., Mr. J. A. Clegg and Dr. C. B. Speedy.

NEWTON CHAMBERS AND CO., Ltd., states that a new arrangement has been made for NCK-Rapier, Ltd., 32, Victoria Street, London, S.W.1, to be the exclusive selling agent in most of the Eastern Hemisphere for the Koehring Company of the U.S.A. NCK-Rapier, Ltd., is the selling organisation for excavators and cranes made by Newton Chambers and Co., Ltd., the parent company, at Thorncliffe Works, near Sheffield, and by Ransomes and Rapier, Ltd., at Waterside Works, Ipswich.

Contracts

THE DECCA NAVIGATOR COMPANY, Ltd., has received a contract to equip twenty-eight Blue Funnel cargo liners with the Arkas J.R.1. automatic pilot.

FIELDING AND PLATT, Ltd., has received an order for three horizontal extrusion presses valued at £250,000 from Aluminium Menziken A.G. of Switzerland.

HENRY MEADOWS, Ltd., of Wolverhampton, has received a repeat order for 300 four-cylinder "330" diesel engines to be installed in "Countryman" tractors by the manufacturers, Chamberlain Industries Pty., Ltd., of Welshpool in Western Australia.

JOHN I. THORNYCROFT AND CO., Ltd., has received an order from The Southampton, Isle of Wight and South of England Royal Mail Steam Packet Company, Ltd., for a twin-screw diesel-engined tug having a length overall of 112ft by 27ft beam.

BROWN BROTHERS AND CO., Ltd., announces that Denny-Brown stabilisers are to be fitted to four Brazilian coastal passenger ships. Two ships building in Spain will have stabilisers built in Scotland and the two building in Yugoslavia will have stabilisers manufactured by the company's German licensees A.E.G./DeutscheWerft.

THE ENGLISH ELECTRIC COMPANY, Ltd., has contracted to build the diesel-electric propulsion machinery for the "drive-on" rail and road ferry ordered from William Denny and Brothers, Ltd., by the New Zealand Government Railways for service in the Cook Strait. Six sixteen-cylinder C.S.V.M. diesel engines will provide a total of 9000 s.h.p. at the twin propellers. For auxiliary power three 450kW diesel-driven alternator sets are to be provided.

THE ENGLISH ELECTRIC EXPORT AND TRADING COMPANY, Ltd., has received an order, worth about £275,000, from the U.S. Department of the Interior to supply two 85,000 h.p. Francis water turbines, for the Bureau of Reclamation's Trinity Power Plant, near Lewiston, California. The turbines will be specially designed to use either of two interchangeable runners; one runner to operate at 426ft head (output 85,000 h.p.) and the other at 334ft head (output 70,000). By using the appropriate runner to suit the considerable seasonal changes in water level in the storage reservoir the plant efficiency will be improved. Design and model testing will be done at the manufacturer's Rugby works and the turbines will be made at the Netherton works, near Liverpool. Delivery to site is scheduled to be made in 540 days and 630 days respectively.

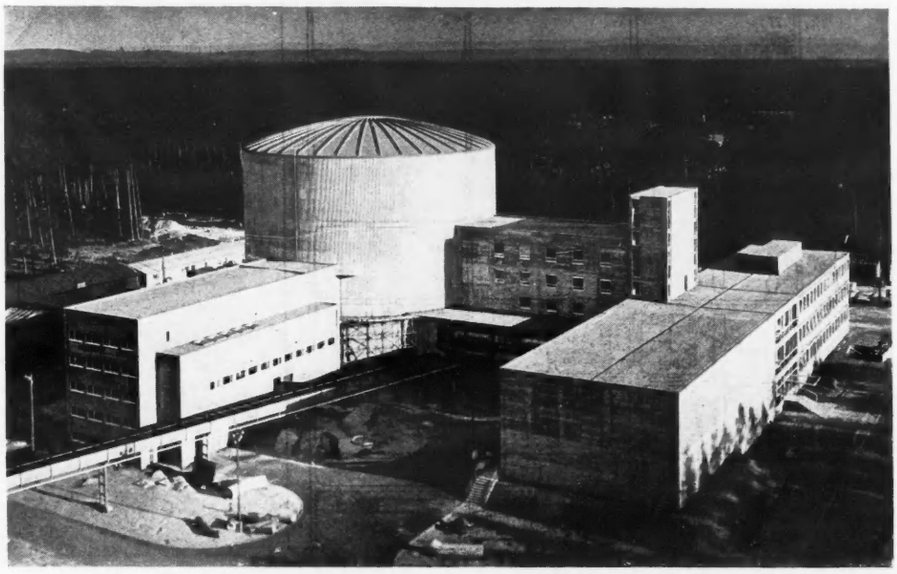
HONEYWELL CONTROLS, Ltd., Greenford, Middlesex, has received an order worth £200,000 covering instrumentation for a Russian chemical works. The £2,000,000 plant is being built by Vickers-Armstrongs (Engineers), Ltd., to the design of Zimmer's, of Frankfurt, chemical process engineers, and will produce chemicals used in the making of nylon. The main contract was placed by Techmashimport of Russia early in 1959. The new Honeywell instrumentation sub-contract includes a 100ft semi-graphic control panel containing full size electronic and miniature pneumatic instruments for controlling temperature, liquid level, pressure and flow. Full instrumentation and installation engineering is included in the contract. There will be seventy temperature control loops, thirty level, thirty differential pressure, and fifty flow and blending loops. Honeywell Controls, Ltd., is being assisted by its German and Italian associates in this project, but most of the equipment will be made at the company's Newhouse, Lanarkshire, factory.

CONTINENTAL AFFAIRS

by Our Continental Editor

Karlsruhe Nuclear Research Centre

After a brief outline of the programme of nuclear developments in the German Federal Republic, the article describes the Karlsruhe Research Centre, which is being expanded into the principal German centre for applied nuclear research. The article goes on to describe the "FR2" reactor which is scheduled to come into service next year.



SINCE the days of the First Geneva Conference for the Peaceful Uses of Nuclear Energy, substantial efforts have been made in the German Federal Republic to make up some of the leeway which the aftermath of the war has occasioned in the nuclear field. Broadly speaking, these efforts may be considered under two headings, nuclear power and nuclear research in general. With regard to the first, there is now under way a programme to install 500MW$_{el}$ in the form of nuclear power stations of about 100MW$_{el}$ each. Projects which are now being actively pursued are a pressurised heavy-water reactor which is being developed by Siemens-Schuckertwerke A.G. (SSW) on behalf of Gesellschaft für die Entwicklung der Atomkraft in Bayern m.b.H., Münich (an association of South-German electricity supply undertakings with participation of the chemical industry); a boiling water reactor with nuclear superheater which A.E.G. is developing for the Studiengesellschaft für Kernkraftwerke G.m.b.H. (SKW), Hanover, and an advanced gas-cooled reactor which Deutsche Babcock and Wilcox is designing for the same organisation (which represents North and North-West German electricity companies). The fourth project under the 500MW programme is the BBC–Krupp high-temperature reactor, a gas-cooled reactor with a core consisting of a large number of spherical fuel elements of graphite and uranium carbide. To this design (due to Dr. Schulten of BBC), a 15MW prototype is now being built near Jülich on behalf of Arbeitsgemeinschaft Versuchsreaktor G.m.b.H. (AVR), an association of communal electricity undertakings.* A 100MW reactor of this kind is envisaged as a second step. Finally, there is the project of an organic-moderated or heavy water reactor, which Interatom G.m.b.H., the joint subsidiary of DEMAG A.G., Duisburg, and of the Atomics International Division of North American Aviation, Inc., is to build for DEMAG.

Additional to the power reactors outlined above is the ship's reactor programme. Three projects are currently in hand, the principal one being the reactor of the Gesellschaft für Kernenergieverwertung in Schiffbau und Schiffahrt m.b.H., Hamburg, which has established a research centre at Geeshacht.† The reactor is an organic-moderated plant which Interatom is to develop within the next two years. Designed to give 10,000 s.h.p., it will be installed in a tanker. Two further projects pertain to a boiling water reactor of Deutsche Werft–AEG and a pressurised reactor of Howaldt–Werke–SSW.

An organic-moderated power reactor of 150MW$_{el}$ is to be built to the order of Arbeitsgemeinschaft Baden-Württemberg zum Studium der Errichtung eines Kernkraftwerkes (AKS). Of two smaller power reactors one is nearing completion while the other is still in the planning stage. The first-mentioned is a 15MW$_{el}$ boiling water reactor. It is being installed at Kahl near Aschaffenburg on the River Main‡ by AEG, the core being supplied by General Electric New York. The owner is the Rheinisch-Westfälisches Elektrizitätswerk A.G. (RWE) which has had the station built chiefly to gain experience and to train personnel.

Investments in connection with the nuclear energy programme, including ancillary industries, are put at DM.2500 million, of which a large proportion cannot be borne by private industry and has to come from the Government. Government help is given particularly at the planning stage, where the federal contribution varies between 33 and 42 per cent. Fifty per cent of the cost of the AVR reactor will be borne by the State.

As part of its industrial programme, Germany is taking part in the Euratom projects at Halden, Norway§, and the "Dragon" high-temperature reactor. The Government is also financing the search for uranium, which has met with modest success, and the processing of uranium ores in an experimental plant. Subsidies or sales guarantees have been given to industrial firms engaged in the production of materials used in nuclear processes. Such substances include pure uranium or uranium oxide, for which Degussa has set up a production capacity of 40 tonnes per annum, pure graphite (Kropfmühl A.G. near Passau), and heavy water—4·5 tonnes per annum liquid hydrogen/deuterium distillation plant of Farbwerke Hoechst; hydrogen/deuterium sulphide two-temperature process of BAMAG. Studies regarding the separation of uranium isotopes by gas centrifuges (Professor Groth, Bonn) are also being subsidised.

This brings us to the second field of activity, research, which at many points connects and overlaps with the first. During the period 1956–59, nearly threequarters of a billion marks have been spent on nuclear research, the various contributions being approximately as follows:

	DM.
Federal Government	520 million
Länder Governments...	100 million
Industry (estimate)	116 million
Total	736 million

Another DM.264 million has been budgeted by the Federal Government for this year, bringing the total to an estimated DM.1000 million.

Karlsruhe Centre

Much of current German research in the nuclear field, especially in the way of basic research, is the task of the universities and technical universities. Reactors for purposes of research and training have been installed at Münich, Frankfurt, and Berlin, and others are under construction.

Compared with these activities, the objectives of the Karlsruhe Research Centre are more in the direction of technology and applied science.

The centre, of which certain sections are already functioning, is being built and operated by the Kernreaktor-Baul-und Betriebs G.m.b.H. (*K*1), an agency in the form of a limited company which was set up in July, 1956 with a foundation capital of DM.60,000,000 and is owned jointly by the Federal Government (30 per cent), the Land Baden-Württemberg (20 per cent) and the Kernreaktor Finanzierungs G.m.b.H. (50 per cent), the latter representing over eighty industrial firms. The capital of *K*1 suffices only to construct the "FR2" experimental and research reactor, an institute for neutron physics and reactor technology, and a few minor installations. Additional institutes and facilities, some of which are already in existence, have therefore had to be financed separately. For this purpose the Federal Government and the Land of Baden-Württemberg on June 26, 1959 set up as a kind of finance corporation the Gesellschaft für Kernforschung m.b.H. (*K*2), with a capital of DM.100 million (since increased to DM.120 million). This step had become

*THE ENGINEER, January 2, 1959, page 35.

† THE ENGINEER, May 15, 1959, page 781.
‡ THE ENGINEER, April 8, 1960, page 624.
§ THE ENGINEER, October 30, 1959, page 531.

CONTINENTAL AFFAIRS *(Continued)*

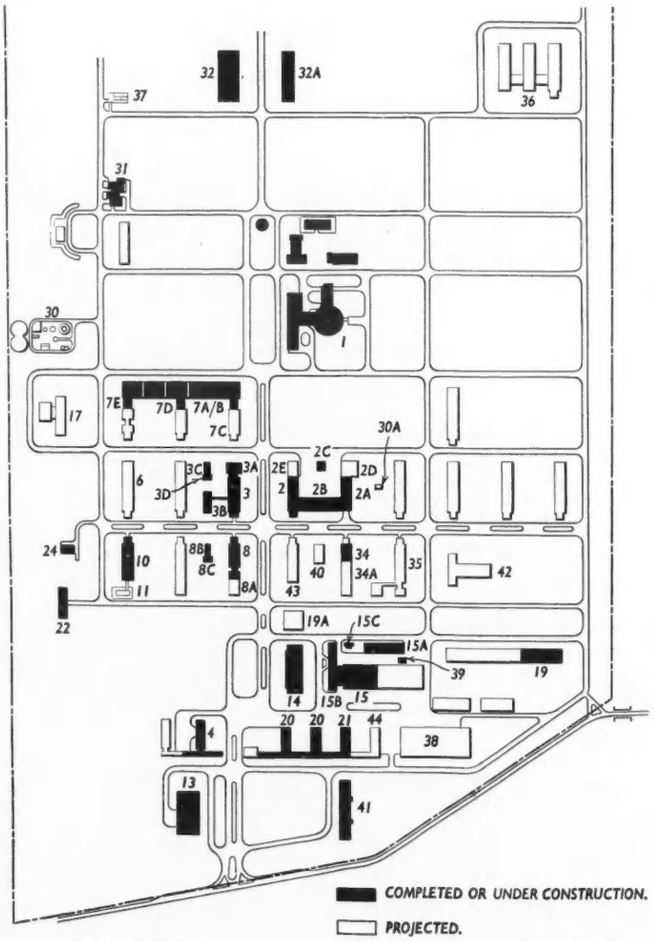


Fig. 1—Karlsruhe atomic research station

1—Reactor building.
2—Institute for Neutron Physics and Reactor Technology.
2*A*—Auditorium.
2*B*—Workshops and laboratories.
2*C*—Transformer substation.
2*D*—Experimental hall extension.
2*E*—Institute extension.
3—Institute for Nuclear Chemistry.
3*A*—Experimental hall for semi-hot work.
3*B*—Training reactor "Argonaut."
3*C*—Waste water collecting plant.
3*D*—Transformer substation.
4—Radiation protection section.
6—Institute for Solid State Physics and Reactor Materials.
7*A/B*—Isotope laboratory, hot section and personnel lock.
7*C*—Isotope laboratory, cold section measurements.
7*D*—Laboratory for Synthesis of Radioactive Compounds.
7*E*—Radio-chemical laboratories.
8—Institute for Nuclear Technology.
8*A*—Institute for Nuclear Technology (experimental hall, including extension).
8*B*—Waste water collecting plant.
8*C*—Transformer substation.
10—Institute for Radio-biology.
11—Laboratories for Neutron Biology.
13—Nuclear Technology Training Centre.
14—Canteen.
15—Main workshop.
15*A*—Subsidiary workshops; painting and carpentry.
15*B*—Electronic laboratories.
15*C*—Transformer substation.
17—Cyclotron.
19—Thermal power house.
19*A*—Temporary power-house.
20/21—Petrol filling stations, motor transport section, garages, fire service and telephone exchange.
22—Water works.
24—Transformer station.
30—Water purification plant.
30*A*—Pumping station.
31—De-activating plant.
32—Institute for Hot Chemistry.
32*A*—Hot laboratories.
34—Institute for the Application of Radiation in Technology.
34*A*—Institute for the Application of Radiation in Technology extension.
35—Institute for the Application of Radiation to Agriculture, including the preservation of foodstuffs.
36—Institute for Transuranic Elements.
37—Dump for radioactive waste.
38—Stores.
39—Test bay.
40—Library, documentation, &c.
41—Administration and drawing-office.
42—Test bays for reactor design.
43—Institute for Nuclear Physics.
44—Chemical stores.

necessary because the industry represented in *K*1 would not agree to a dilution of its influence through the influx of further public money. In addition to *K*1 and *K*2 the following bodies own installations at the Centre: Karlsruhe Technical University (approximately DM.5,000,000), Isotopen-Studiengesellschaft e.V. Frankfurt/Main (approximately DM.500,000), and Euratom (approximately DM.50,000,000). About a year ago, the centre employed slightly over 600 persons, of whom 24 per cent were academically qualified scientists and engineers, 42 per cent skilled technical personnel, and 33 per cent administrative personnel. The total figure will rise this year to about 950. As elsewhere in Germany, the shortage of scientific workers is severe in the age group forty years to fifty years, less so as regards younger people. Specialist training is given in the various institutes, which also run courses for engineers, chemists, survey and safety engineers and others. A school of Nuclear Technology is being formed.

Layout.—The research centre is situated near Leopoldshafen in the Hardt Forest, about 12km north-north-west of Karlsruhe, on a site which extends over 140 hectares, providing ample room for future expansion. Clearing work began on April 13, 1957. Fig. 1 shows the stage reached by last November.

The principal installations, completed or under construction, at the present time include the "FR2" research reactor, to be described in more detail later in this article, the main engineering workshops and other service installations, an institute for neutron physics and reactor technology, an institute for radio-biology, and an institute for radio-chemistry. There is in addition an institute of nuclear technology, equipped with a 47MeV deutron cyclotron, which is a department of Karlsruhe Technical University, and an institute for the technical applications of radiation which belongs to the Isotopen-Studiengesellschaft.

Further installations and institutes which will be erected include an experimental area for reactor construction, "hot" cells, an electronic laboratory, an isotope laboratory, a laboratory for synthesising radioactive compounds, an institute of solid state physics, an institute for "hot" chemistry, an institute for neutron biology, an institute of nuclear physics, the "Argonaut" research reactor, particle accelerators including a cyclotron, a school for nuclear technology, and a library and documentation centre, An institute for trans-uranic elements is being formed by Euratom, and a federal institute for the application of radiation to the preservation of foodstuffs is also to be built.

The work of the Institute of Neutron Physics and Reactor Technology (INR) centres on technical investigations, of which may be mentioned research in temperature stress in fuel elements such as those used in the "FR2" which develop a thermal flux of up to 50W per cubic centimetre of uranium and up to 90m for square centimetre. By means of induction heating, sections of elements can be tested at outputs of up to 200m per cubic centimetre. Two set-ups allow the generation of neutron pulses which are at present required for measuring the physical properties of graphites and organic moderators. Neutrons are decelerated from 1×10^7m/s to 2×10^3 m/s (thermalisation).

The fuel arrangements inside the "FR2" are being investigated by means of a sub-critical experiment (Fig. 3) and a method for applying neutron pulses to sub-critical assemblies is to be developed.

Design of the "FR2" itself has been the task of an INR team under the direction of Professor Dr. K. Wirtz, the chief of the Institute. A mathematical department equipped with an electronic calculating machine is engaged on programming calculations of reactor performance, taking into account the kind of fuel and the moderator employed (in the "FR2", uranium and heavy water) as well as the presence of canning materials and the existence of a whole spectrum of neutron velocities. A special aspect is the determination of absorption cross-sections. The development of a breeder reactor is one of the future tasks of the institute.

Besides basic research and the training of young scientists, the Institute of Radio-Chemistry is concerned with technical radio-chemical processes and the applications of tracer techniques. A zero-power reactor of the type "Argonaut" is to go into operation soon.

The institute of Nuclear Technology is mostly concerned with methods for the production of heavy water and the enrichment of uranium with U235. A process for the production of D_2O is stated to have reached the pilot plant stage. Basic research includes ultrasonics, low temperature physics, and mass spectrometry.

The work of the Institute of Radio-Biology is concerned with protection against radiation effects and falls into two main categories, viz. the effects of radiation upon the biological "units" (genes, chromosomes, viruses, enzymes); and studies of the metabolism of radioactive materials, with a view to their quick elimination from the body.

"FR2" Research Reactor

The principal source of radiation at the Karlsruhe Research Centre will be the "FR2" reactor (title illustration) which is due to go critical early next year. Based on the "NRU" reactor at Chalk River, Canada, the "FR2"—an earlier design, the "FR1," never proceeded beyond the drawing board—will have a mean neutron flux in the core of $7 \cdot 5 \times 10^{13}$ neutrons/cm² sec., and a maximum thermal neutron flux in the moderator of 3×10^{13} neutrons/cm² sec. The maximum fast neutron flux amounts to 3×10^{13} neutrons/cm² sec., and the total thermal output is 12MW. The

main design data are summarised in Table I.

TABLE I.—*Principal Design Data, "FR2" Reactor.*

Multiplication factor	$k_\infty = 1{\cdot}22$
Neutrons produced per absorption	$\eta = 1{\cdot}32$
Fast fission	$\varepsilon = 1{\cdot}035$
Thermal utilisation...	$f = 0{\cdot}969$
Resonant escape probability... ...	$p = 0{\cdot}924$
Escape factors with control channel (diameter 130mm) :	
	p fast $= 0{\cdot}948$
	p slow $= 0{\cdot}943$
Sum of temperature coefficients =	$-2{\cdot}2 \times 10^{-4}$ per deg. Cent.
Reactivity balance :	
$k_\infty = 1$	22 per cent
Escape losses without control channel	—10 per cent
Escape losses with control channel	—10 per cent
Samarium	—0·9 per cent
Xenon	—2·1 per cent
Temperature	—0·6 per cent
Output :	
Average neutron flux in uranium	$7{\cdot}5 \times 10^{12}$n/cm²sec.
Maximum thermal flux in moderator	3×10^{13}n/cm²sec.
Maximum fast neutron flux ...	3×10^{13}n/cm²sec.
Total thermal output	12MW
Maximum surface loading of elements	90W per square centimetre
Maximum can temperature ...	80 deg. Cent.
Cooling water inlet temperature	36 deg. Cent.
Cooling water outlet temperature	45 deg. Cent.

Fig. 2 shows a horizontal section through the reactor core. The charge consists of 5 tonnes of natural uranium moderated by 17·8 tonnes of heavy water. As the illustration shows, the fuel and breeder rods are inserted vertically, forming a square pattern with 196 positions, with centres spaced 168mm apart. Altogether up to 158 positions will be occupied by uranium fuel and thirty-four by thorium breeder elements. Both kinds of elements take the form of rods of 32mm diameter and 2160mm length. They are canned in 10mm thick aluminium and surrounded by a 1·5mm thick aluminium shroud, with a 4mm wide space in between to give a chimney effect. The maximum surface loading is 90W per square centimetre, and the surface temperature, 80 deg. Cent.

Between these elements, at the centre points of the grid, can be arranged up to sixteen combined trim and shut-down rods, 50mm in diameter and 2100mm long, and one fine control rod. Altogether there are forty-one such positions, which can be used for control rods or as isotope channels. A drilled plate at the bottom of the tank locates the ends of the rods.

The whole core assembly is placed in an aluminium tank of 3100mm internal diameter and 2560mm height from the bottom to the inner surface of the lid. This tank is surrounded by an outer mild steel tank with bottom and walls 12mm thick and heavily lead-plated. All internal fittings are either of stainless steel or lead-plated.

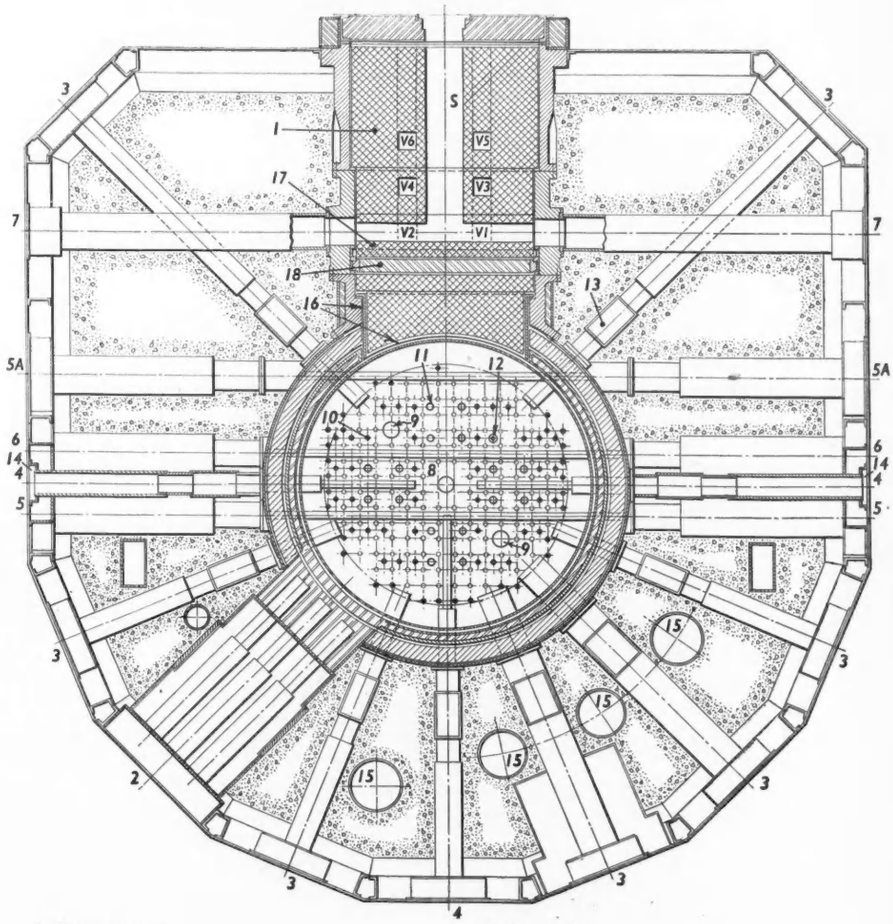
Perhaps the principal difficulty of manufacture lay in the provision of a large number of experimental channels which had to pass, in a horizontal direction from several angles, through the biological shield, the 15cm thick cast-iron thermal shield, the reactor tank and its liner, and into or through the core. Altogether, there are ten channels, with thimbles ending in the core, as well as one tangential and two central through channels (" rabbit holes "), in addition to which one central channel of 130mm diameter and two subsidiary vertical through channels are provided. There is, moreover, a thermal column and an instrument column.

Cooling water connections are made to the bottom of the tank. The experimental radiation channels can be plugged by plugs which can be raised or lowered from above. In the top parts of the biological shield are situated four circular manifolds from which pipes emanate to the various experimental channels for closed circuit exhaust ventilation.

The biological shield, which surrounds the thermal shield, is internally cylindrical, on the outside of irregular polygonal shape, and on average 2500mm thick and 9400mm high. It comprises a steel shell, internally 15mm and externally 12mm thick, which after complete assembly of the rest of the equipment will be filled by hand, to ensure maximum packing, with magnetite ore which will finally be grouted in position, so as to give a heavy concrete with a density of 4 tonnes per cubic metre.

At the top, the reactor is shielded by two heavy concrete lids and a cast-iron rotatable lid, and at the bottom, by the 1·8m thick main floor of the reactor building.

The reactor will be cooled by circulating the heavy water moderator, of which the whole



1—Thermal column
2—Measuring column.
3—Experimental duct into reflector.
4—Experimental duct into core.
5—Experimental duct through core.
5A—Experimental duct tangential to core.
6—Experimental duct through core (pneumatic post)
7—Experimental thermal duct horizontally through thermal column.
8—Central vertical duct.
9—Off-centre vertical ducts.
10—Isotope ducts.
11—Trimming/shutdown rod.
12—Fine control rod.
13—Radiation plug.
14—Airtight plug.
15—Shaft for loop.
16—Aluminium window.
17—Movable radiation shield (steel).
18—Movable radiation shield (lead-boral).
V1 to V6—Vertical ducts through thermal column.
S—Horizontal duct through thermal column.

Fig. 2—Horizontal section through core of " FR2 " research reactor

system will contain a total of 23 tonnes. At the inlet, the coolant will have a temperature of 36 deg. Cent., and at the outlet, 45 deg. Cent.

As usual in reactor engineering, some very exacting tolerances have to be maintained. Thus, the thimbles of the experimental tubes are welded to the outer steel casing of the biological shield and connected by watertight flanges to the inner casing ; these thimbles have to be straight within 0·66mm per metre. The reason is that they have to accept radiation plugs as well, as in some cases, quite long experimental tubes. These tubes have to be guided in a straight direction to avoid damaging the aluminium tank. Dimensional accuracy must be maintained after the shield has been grouted, when corrections are no longer possible.

The same kind of difficulty crops up in the construction of the thermal column. This contains a total of twelve experimental tubs of different cross sections (six vertical, five horizontal-radial, and one horizontally-tangential " rabbit "). The graphite of the columns can be removed on a carriage to create space for irradiation experiments requiring a large beam section. Airtight seals have to be fitted to prevent the escape of radioactive gases, and since rubber is unsuitable, the seals have to be made of metal, which again involves great accuracy of manufacture considering the size of the object. At the same time, the walls, which are 110mm to 250mm thick, must be free from flaws to give protection against gamma radiation, and the homogeneity has to be checked by careful tests with ultrasonics and gamma ray photography.

Liners for the vertical shafts in the biological shield, for the insertion of plugs, have a minimum daylight section of 250mm by 250mm and a length of about 4m. They are fabricated in special jigs and after assembly have to be sprayed with aluminium metal, as well as the assembly welds. In these cases, as well as with many aluminium clad parts involving sharp angles and deep recesses, attention had to be paid to the accessibility of the welds. Pipework constructed of " V2AE " and " V4AE " stainless steel was bent cold, and argon-arc welded. During the welding the inside was protected by filling with process gas, in order to obtain flawless welds. Since the interior seams had to be ground flush, the welds had to be arranged to make this possible, or else flanges with ring gaskets or welding lips had to be provided. All austenitic welds had to be X-rayed and any tungsten inclusions arising from the argon-arc process had to be removed, in accordance with American regulations. So as to prevent the possibility of cracking due to strain hardening, the stainless tubing was then heat-treated and the tempering colour removed by pickling. Finally pressure testing was carried out and a halide leak detector test was applied.

The reactor core and the thermal shield are supported on a circular steel base grouted with the concrete at approximately main floor level, 9·25m above ground floor. This base plate has a diameter of 4100mm and has to be horizontal to within 0·5mm, in order to permit fuel and control rods to be inserted vertically without jamming.

BUILDING

The reactor is completely enclosed by being housed inside a 36·2m high dome comprising cylindrical concrete shell of 38m internal

CONTINENTAL AFFAIRS *(Continued)*

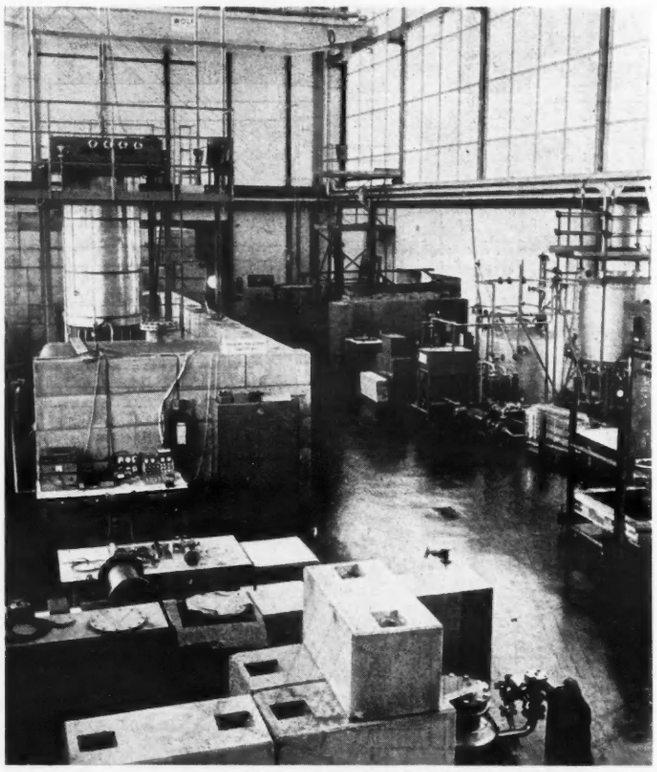


Fig. 3—Experimental hall of the Institute for Neutron Physics and Reactor Technology. Left, sub-critical experiment

diameter and 9·25m height surmounted by a 23m high steel shell with 4m high top forming a spherical segment of 45m radius. The shell is gastight, with a leakage rate not exceeding 1 per cent of the total volume per day under an excess pressure of 50mm water gauge, in order to retain practically the whole of the very high radioactivity—70,000,000 Curie—which could conceivably be set free in a serious accident. The design can withstand an internal pressure of 1500mm w.g. which, however, would presuppose the sudden evaporation of half the heavy water in the reactor. Normally a negative pressure of 20mm to 40mm w.g. is always maintained inside, and airlocks are provided to give access, including a large one for lorries.

In addition to its own weight, the shell is subject to loads arising from the operation of a 60-tonne travelling crane installed near roof level on a circular track. These loads can amount to a dead load of 160 tonnes (including the weight of the crane itself), plus horizontal radial or tangential live forces of about 14 tonnes, due to braking of the crab and crane, or sudden stoppage of the driving motor.

The usual solution, to support the crane on peripheral columns, could not be adopted for lack of space, and therefore the loads are carried by the steel shell itself. The crane runs on a circular box girder of square section which is welded to the inside of the shell and acts as a stiffening frame. The crane track is 17m above the shell base or 26·75m above ground level. A second ring at a height of approximately 7m, about 16m above ground level, which serves as an inspection catwalk, supplies further stiffening. Eight vertical internal ribs, also of box section, stiffen the top part of the shell above the crane girder. The roof is stiffened by a number of radial ribs extending from the edge to a ring at the centre of about 4m diameter. Into the corner between cylindrical shell and domed roof an internal gusset ring is welded which, together with them, forms a triangular box section of great torsional stiffness, capable of transmitting the comparatively large buckling loads and torsional mounts which a large internal pressure would cause.

Since the maximum stresses in the 14mm thick steel shell amount to only about 200 kg per square centimetre, the problem was principally one of adequate resistance to buckling. The effect of the quite heavy crane loads in this respect is equalled by the comparatively small radial forces due to wind and negative internal pressure. Admissable distortion of the plates in assembly had to be limited, by means of special jigs and appropriate welding procedure, to 0·8 per cent of the buckling length, and in any case was not allowed anywhere to exceed 0·1 per cent of the diameter of the building.

The lower concrete part of the reactor building is on three main levels: basement, with foundations at −6·2m, ground level, and reactor main floor at +9·25m; there is also an intermediate level at +3·8m. The underside of the reactor is at +6·85m. By the side of the reactor and flush with its top are "hot" storage facilities. Fuel elements can be extracted into a vertical lead-shielded transport coffin mounted on wheels and transferred from the reactor to the store.

The erection of the reactor and the biological shield is being carried out by Dinglerwerke Aktiengesellschaft, Zweibrücken, which also supplied the steel shell for the biological shield, the thermal column, the instrumentation column, and the base ring supporting the core. The same firm was responsible for the design and construction of the steel shell of the reactor building.

New Life for Polluted Lakes

Pollution problems in Britain are mostly concerned with streams and rivers. In Sweden, many of the country's lakes suffer from lack of oxygen. Fish and vegetation are dying out and the waters begin to smell musty and become useless for supplying water or bathing. To remedy this state of affairs, a programme to restore the oxygen in lakes has now been embarked upon by the Swedish public health authorities. The method is based upon research undertaken by Industriförbundets Vattenvårdsbyrå in co-operation with Atlas Copco. Experiments carried out last summer at a lake called Långsjön showed very encouraging results. Before treatment, the dissolved oxygen content of the water was zero, whereas plant life and fish require about 17 per cent on a minimum. Compressed air was introduced into the water through a perforated plastic hose 546 yards (500m) long, which was laid at full length on the lake bottom from a rowing boat. A small air compressor consuming 8 h.p. to 10 h.p. supplied the air. After less than three weeks the dissolved oxygen content of the water had risen to 57 per cent and new plant life was beginning to establish itself.

When the experiments began there was a difference in temperature of 12 deg. Cent. between the water at the surface and that at the bottom. In three weeks the turbulence induced by the compressed air had removed this difference.

Operations ceased with the onset of the 1959–60 winter, but were restarted last spring. The experience has been so promising that the compressed air method will soon be tried in most of Sweden's "panting" lakes. The method is considered to be most useful in solving acute problems of pollution, especially if its application is followed up by the construction of an efficient purification plant. It is pointed out that the water is oxygenated not by the compressed air itself, but by the waves created by the pumping action of the air as it forces its way to the surface. The waves pick up the oxygen from the atmosphere—hence the description "self-help," which has been coined to describe the mechanism. Among compressed air projects to be tried in the near future are those at the town of Torshälla and at Munksjön. One hazard to be guarded against is the release of hydrogen sulphide which may be present in the lower layers of stagnant water. To forestall this possibility it is necessary to examine carefully beforehand the water as a whole, and particularly the bottom layer, to see whether hydrogen sulphide is there. At present it is considered a moot point whether purification should cease in winter. Compressed air purification closely resembles the method adopted for keeping channels ice-free when the temperature drops below freezing point, a process now successfully in use in Canada, the United States, Greenland and Sweden. While the prevention of ice formation may not earn the approval of skaters, it does provide water-holes for birds and air-holes for fish.

Suction-Dredger "Ramses"

In June the suction-dredger "Ramses", 4000 gross tons, returned from Lübeck to the Suez Canal. As "Paul Solente" she was sunk at Suez in November, 1956, later refloated and towed to Lübeck for refitting. Owing to long submersion the machinery was no longer in a usable condition. It was decided at the time to replace the obsolete slow-speed diesels and separate Ward-Leonard drives for the propellers and dredging pumps by modern equipment. The propelling and dredging machinery supplied by Orenstein-Koppel und Lübecker Maschinenbau A.G. and Siemens-Schuckertwerke A.G. includes two main motors of 2700 s.h.p. each, giving a speed of 13·5 knots, and two suction pumps each powered by a 750 h.p. electric motor. These units are supplied by four high-speed diesel generator sets each giving 1800kW at 800 r.p.m. The sets are connected in series, so that the load is evenly spread over all four generators, while each motor can have its speed controlled independently of the rest; adjustment of load as between Leonard sets is not necessary.

The vessel's mains electricity is supplied by generators having a total capacity of 800kW. All equipment had to be specially protected against the sandstorms which are very common on the Suez Canal. All cooling air is obtained from the engine room, drawn through special filters, and cooled by sea-water.

THE AMERICAN SCENE

by Our American Editor

Applications of Automatic Data Processing at the N.B.S.

No. II—(*Concluded from page* 332, *August* 19)

In the field of automatic data processing systems the National Bureau of Standards serves the U.S. Government as a central research and development agency and a readily available source of technical information. The scope of the programme in data-processing applications and equipment design is illustrated in the development of methods for solving specific problems in both scientific and management areas, explorations of the potentialities of computers, logical design of computing systems, development of special circuitry, and evaluation of electronic components. This programme was initially established to assist the Bureau and other government agencies in finding solutions for their data-processing problems and has now grown with the electronic computer art to include a wide range of research and development activities.

Packaged Switching Circuits

THE Bureau has developed a number of special-purpose transistorised computer packages (Figs. 9 and 10) that are expected to help "automate" many of the data recording and preliminary processing tasks encountered in its scientific operations. These versatile "building blocks" can be connected together systematically to accept raw data from experimental equipment and to transpose these data into a form suitable for input to a high-speed electronic computer. Each assembly of packages can be tailored to fit the special requirements of the project, and can be used at the site of the experiment. The output from the system can be fed directly to a computer, recorded on a suitable medium for computer input at a later time, or used to drive display equipment that will keep the engineer informed of the progress of his experiment.

The accelerating pace of current scientific effort and the need for conserving technical manpower both emphasise the value of automatically recording and computing experimental data. Much human effort is spent in the simple repetitious tasks of taking data during an experiment and then performing large volumes of manual calculations. By "automating" the routine data-handling aspects of scientific experiments, savings of time and labour, as well as increased quantity and reliability of work output, can be realised both in basic exploratory research and in routine calibration and testing.

In surveying its own data-handling instrumentation problems, the Bureau decided that it could best meet its needs at this time with a series of flexible logical building blocks to record and perform preliminary processing of much of its data. These blocks can be used where: (1) data are produced in large volumes ; (2) data taking is extremely fast, extremely slow, or extremely precise ; (3) a need exists to minimise human error, tedium, and eyestrain ; or (4) computation is extensive. So far, seven specialised major building blocks have been developed : A flip-flop, gating circuitry, a "one-shot" pulse generator, a logical OR-inverter, an indicator, an analog switch, and a power gate driver. They are, of course, compatible with each other and all operate at the same 50 kc/s pulse repetition rate. Each package is constructed on a 4in by 5in plug-in printed board, and uses electronic components that are common stock items to avoid replacement problems. Most of the packages contain type 2N414 transistors and some contain types 2N363 or 2N123 transistors. The power supply requirements are : (1) −12V ; (2) +12V ; (3) a reference voltage for the analog switch ; and (4) any other special voltages that drive external electromechanical devices. In most of the packages, some components or subassemblies are left unconnected, and must be wired externally to the package. Connecting these components externally allows greater flexibility in combining them.

The flip-flop package consists of two bistable flip-flop circuits and the necessary logical gating for converting each to one of several modes of operation. A normally open switch can be connected to the collector of either transistor to reset the flip-flop. In each package is also sufficient circuitry to construct one bit of a double-rank shift register or two bits of a serial shift register. The output of the package can drive five other flip-flops five OR-inverter circuits, eight gate resistors, or five gate capacitors.

The gating package contains eight logical gating circuits consisting of resistor-diode networks with capacitor inputs. They are mainly to supplement the gates in the flip-flop packages to complete the component requirements of shift registers, counters, or other systems. They can transfer information from a shift register or form feedback paths in various counting configurations. These gates can be driven by the output of a flip-flop, a "one-shot" pulse generator, an OR-inverter, or a power driver. The pulse generator can deliver a single pulse whose duration is variable from 20 to 10,000 micro-sec. Regardless of the duration of the pulse, the circuit is prepared to generate a new pulse 20 micro-sec after the initiation of the first pulse.

The package consists of a flip-flop identical to the one in the flip-flop package, together with an integrator, a discriminator, and an amplifier. After the flip-flop is triggered, its output is integrated. When this integrated signal reaches a predetermined level, the discriminator is triggered. Its output is differentiated, amplified, and inverted, then differentiated again before being fed back to reset the flip-flop. The output of the package, which can be either positive or negative, has the same driving capabilities as the flip-flop package. Each of the OR-inverter packages, which can also be used as an AND-inverter, contains four separate four-input inverter circuits. For negative input pulses, the four-input diodes function as an OR-gate ; for positive inputs, the diodes serve as an AND-gate. The output of the gate is amplified and inverted. One of these packages can drive 6 other similar packages, 6 flip-flops, 8 gate resistors, or 6 gate capacitors.

The indicator package contains circuitry for driving 10 incandescent lamps rated at 12V, 18 mA each. This package can also drive electromechanical equipment within the power limits of its 2N363 transistors. The analog switch package contains one flip-flop that controls an analog switch capable of switching up to plus or minus 10V within 5mV of the input. By proper selection of an output resistor, the switch will present an analog voltage corresponding to a specific input quantity or digit.

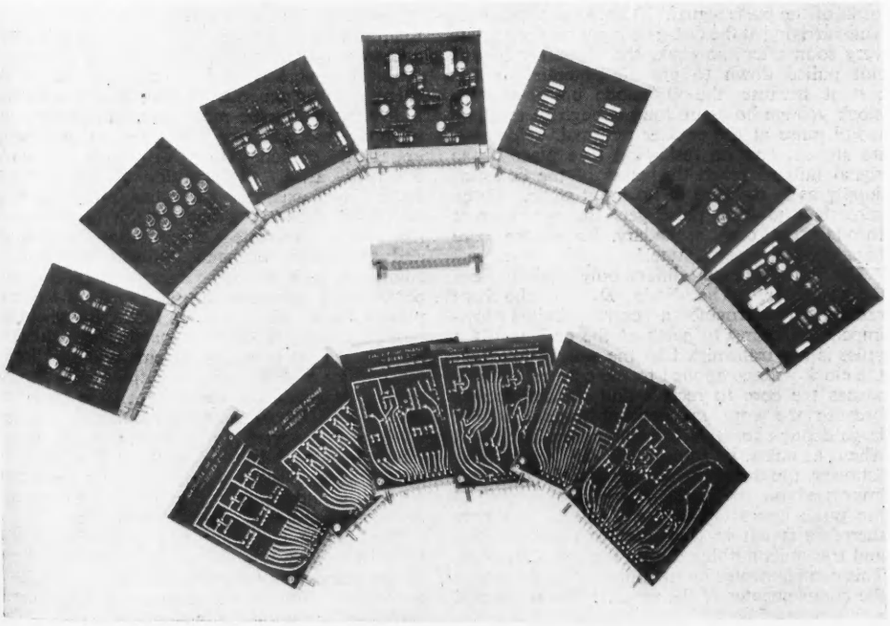


Fig. 9—Computer packages developed to perform logical operations required for electronic data processing

THE AMERICAN SCENE *(Continued)*

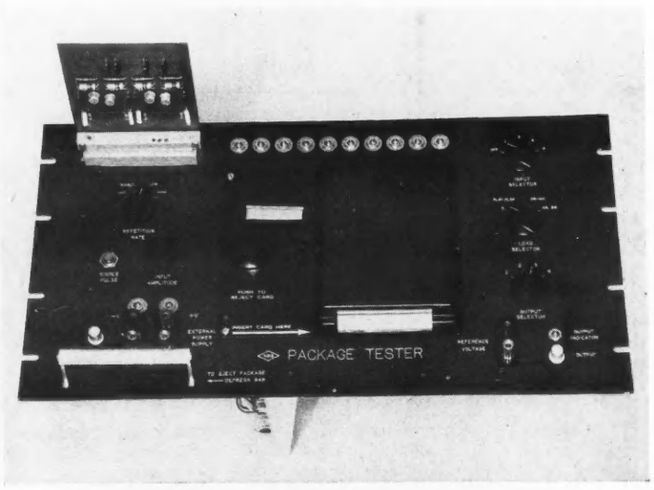


Fig. 10—Punched card instrument for testing computer packages under simulated operating conditions

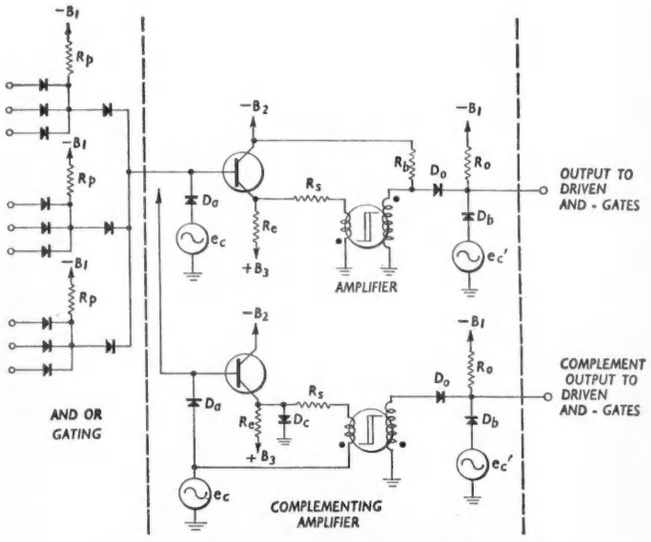


Fig. 11—Circuit diagram of transistorised magnetic core

The power gate driver is designed to supplement the output driving capabilities of other packages. Where the output of a particular package may not have sufficient power to drive all the gates required by the system design, the gate driver—containing a number of amplifiers—can be added to drive as many as 40 other gates.

Improved Magnetic Core Digital Circuitry

Continuing research on electronic computer circuitry and components, conducted for the U.S. Air Force Cambridge Research Centre, has resulted in an improved digital magnetic amplifier. Semiconductor diode gating, because of its economy, flexibility, and dependability, is widely used to perform the logical functions of a high-speed electronic computer. To overcome the loss of signal power through the gates, amplifiers are inserted into the gating structure at intervals to regenerate the signal. Although vacuum valves and transistors are commonly used to amplify the signal, saturable core reactors also show promise. The Bureau has therefore been investigating the use of these components as amplifiers because of their compactness, dependability, and low power consumption.

Essentially, these amplifiers consist of diode-resistor networks associated with miniature saturable-core reactors driven by a "clock." The "clock" in this case is a 300 kc/s low-impedance sinewave source. An amplifier serves to transmit pulses, corresponding to binary "ones," or no pulses "zeros" depending on the input to the stage. The circuit diagram of a magnetic core amplifier with associated circuitry is shown in Fig. 11. Between the vertical dotted lines are two stages; the upper stage is an amplifier, and the lower one is a complementer. Outside of the dotted lines are diode-resistor networks to provide the logical AND-OR gating. The stages can receive an input signal from the OR-gate.

Most of the power gain of the amplifier is provided by the saturable core reactors. Current from clock e_c', together with the total current from R_o and all the resistors of the driven AND-gates in parallel, serve to return the reactor to the state of negative saturation during each half-cycle of e_c'. During the positive half-cycle, e_c' has no effect on the reactor because the diode D_o is back-biased. The reactor, left to itself, remains negatively saturated once put in this state and presents such a low impedance to the driven AND-gates that they remain held at ground level during the negative half-cycle. Thus, binary zeros are transmitted. If the AND-gates at the left of the diagram are not held at ground level during the negative half-cycle of e_c, which is opposite in phase to e_c', a negative signal reaches the input winding of the reactor. Since this winding is in the opposite sense to that of the output, the negative signal saturates the reactor in the positive state during the positive half-cycle of e_c'. Finally, during the ensuing negative half-cycle of e_c', the driven AND-gates return the reactor from positive to negative saturation. The reactor then presents a high impedance to the gates, so that they are not held at ground. The gates therefore transmit binary ones.

The transistor emitter follower, having nearly unity voltage gain, does not change the basic operation of the original circuit. However, it does improve the volt-second transfer function, and provides additional current gain. The current gain increases the logical gain of the stage and lowers the power expended in the interstage logical network. The improved volt-second transfer characteristic results from transistor base-charge storage which in turn results from driving the transistor into saturation at the peak of the pulse signal. Then, even though the pulse arriving at the OR-gate input may terminate very soon after the peak, the transistor base is not pulled down to ground potential at this instant because the OR-diode opens and the clock voltage holds up long enough to result in a full pulse at the emitter terminal. However, no storage and no reshaping take place if the signal fails to reach the value of the collector supply as in the case of no input pulse. To be sure that no false pulse gets through, current through the core secondary biases the core toward its "unset" state.

The complementer differs only slightly from the amplifier. The diode D_c and the base resistor R_e provide a current-limited low-impedance clamp to earth at the emitter. If a pulse is not transmitted by the emitter follower, the clock voltage applied to the core continually causes the core to receive and transmit pulses because the core magnetising current is not large enough to open the clamping diode. But when a pulse is transmitted by the emitter follower, the diode opens, and the clock voltage impressed on the core directly is opposed by the pulse appearing at the emitter. The core therefore is left in the unset or no-pulse state and transmits nothing during the next half-cycle. This complementer inserts only half-cycle delay; the complementer of the original circuit inserted a full cycle of delay.

The final improvement in the previous circuit is the output AND-gate consisting of a resistor R_o and two diodes, D_o and D_b. The value of the resistor is adjusted to provide sufficient current to drive all the earth capacitance of the connecting leads which run from the amplifier or complementer to all the gates driven by them. As a result, the current carried by a driven gate never need be greater than is required by the core directly associated with it. A single stage can drive as many as thirty other stages. The total power input to an amplifier or a complementer is about 0·5W and the power per singly loaded AND-gate is 0·15W. The clockpower per core is approximately 50mW.

N.B.S. Analog Computer

The Bureau maintains an analog computer (Figs. 13 and 14) for the solution of problems that arise in connection with its scientific programme. This machine has proved to be a valuable research tool because of: (1) its ability to accept and produce information in the form of continuous plots; (2) the rapidity with which setup and parameter changes can be made; and (3) the clear picture of the physical relationships that it presents. It permits engineers and scientists to simulate complex equations or physical problems and save many hours of calculation or experimentation, thus freeing the individual to pursue more rewarding tasks. In scientific research, new problems not previously apparent, contemplated, or easily solvable frequently arise. The solution of one problem reveals the existence of other more difficult problems whose solutions require the development of sophisticated computation techniques and specialised mechanical aids. The analog computer, with its wide variety of built-in computational capabilities, has shown itself to be a powerful and essential aid in furthering scientific research. The machine is particularly suitable for handling dynamics problems and the linear or non-linear differential equations of lumped-parameter systems in one independent variable. It can also be used for curve-fitting and for analysing a variety of transcendental, trigonometric, algebraic, and partial differential relations. Very large or very small numbers can be scaled, and answers can be obtained to two and sometimes three significant figures.

The analog computer is also useful to the scientist who wants to simulate quickly some of the processes that may occur in an elaborate experiment without performing the experiment itself. By analysing the results obtained with the computer, he can change variables in the simulated experiment to improve his design and save

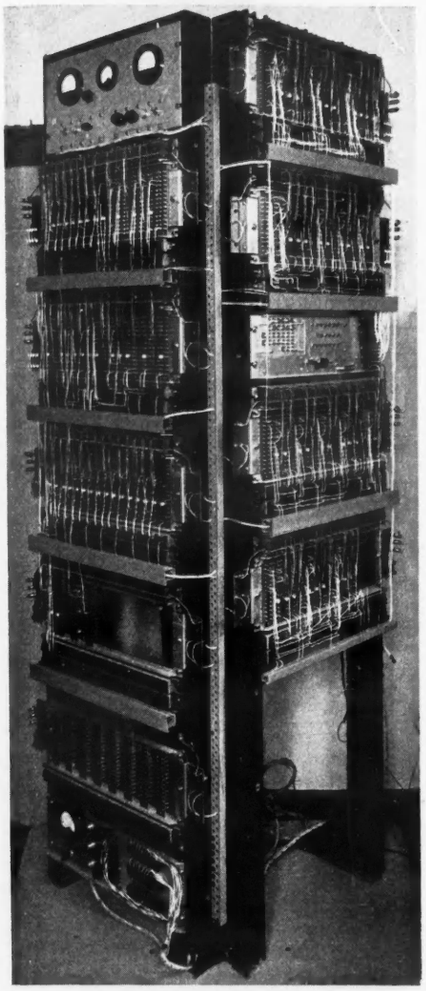


Fig. 12—Test computer using eighty-one magnetic cores and a seven-place shift register internal storage

the time that might otherwise be lost in fruitless preliminary trials in the laboratory. The problems worked on the analog computer illustrate the wide variety of mathematical and physical processes that the machine can simulate, analyse, or evaluate. For example, the analysis of a zone-melting operation required setting up a mathematical model of the physical process and then solving the equations on the machine. The results indicated the optimum heating conditions for a particular metal sample. In another case, the machine performed a Fourier analysis of some waveforms produced by an electronic oscillator ; the results enabled the experimenter to select among a set of components the best to suit his needs. As a further example, the machine manipulated a function of two independent variables to produce a set of contours corresponding to that function—and then drew the contours on an *X-Y* plotter. These and other problems are representative of those solved and are discussed further below.

Zone melting is a practical method for preparing extremely pure metals in small amounts. The Bureau, as part of its standard samples programme, is investigating this technique to produce ultra-pure tungsten. Since even partially purified tungsten is very expensive, it is desirable to know before trying experiments, how the material will behave during the zone-refining process. It was not known with certainty whether the melting at the narrow heated surface of a tungsten rod would proceed axially or vertically, or whether the molten portion would adhere or drip off. These conditions are influenced by heating rate, rod diameter, thermal conductivity, emissivity, latent heat of fusion, and surface tension.

Heat flows radially inward and axially up and down by conduction ; it also flows radially outward by radiation, at a rate measured by the Stefan-Boltzmann fourth-power law. When the melting point is reached at any specific location, the temperature rise halts briefly while the latent heat of fusion is absorbed, and then continues at a slightly different rate. The machine must consider the relations between all of these numerous variables. All variables can be assigned numerical values, and the values can be inserted into the machine. The course of a typical melt can then be followed on the time/temperature curves drawn by the computer. With all parameters fixed except for the heat input, trial runs were made for different heat input values until one was found that gave a satisfactory time-of-melt for the proper shape of melting zone. The procedure was repeated for five rod sizes whose dimensions were read in by a simple resetting of the dials on the computer.

The Bureau's electronic laboratories recently designed a crystal-controlled oscillator to have a stable output rich in harmonics. Any individual harmonic can be selected from the output with an *L-C* filter of appropriate design. In developing the oscillator, it was necessary to know the amplitude and frequency of the principal harmonic components to be sure that the circuit would have a useful output signal. Commercial wave analysers will provide this information, but only for lower frequencies. At the higher frequencies generated by this oscillator, only a Fourier analysis of the recorded waveform is possible.

Selecting a crystal for the most desirable and useful harmonic output is a trial-and-error procedure. Twelve different crystals were tried, and the waveform generated by each was recorded from an oscilloscope. To avoid the tedious and not-too-accurate method of hand analysis, the curves were analysed by the analog computer to provide a basis for selecting those crystals serving best the needs of the equipment designer. Fine copper wire, held in place by gummed tape, was laid out in the form of one such curve on the table of an *X-Y* function generator. As the *x*-coordinate was swept by an analog voltage, an r.f. head followed the wire to determine the *y*-voltage. Using the values for *y*, the computer generated sine and cosine functions from the equation $y = -\omega^2 y$, and integrated the products to find a numerical value for one Fourier coefficient. When two voltage dividers were reset to provide a different value of ω, the procedure was repeated. The procedure continued until the machine had obtained ten coefficients, and each curve was analysed similarly.

Automatic Literature Searching

The Bureau and the U.S. Patent Office have been cooperatively studying the technical aspects of patent searching to find methods for mechanising as much as possible the search process. One of the major tasks in this effort has been to develop a programme for automatic searching of patents by making use of an electronic computer. This programme is known as " HAYSTAQ," and has resulted in an experimental system designed for the storage, search, and retrieval of technical literature, particularly in the field of chemistry. Although systems of the " HAYSTAQ " type will not eliminate completely the manual literature search required of a patent examiner, they may be expected to reduce such search to relatively few documents.

The " HAYSTAQ " system simulated on an electronic computer certain features of the manual search which a patent examiner now makes ; this system has been programmed for the " SEAC " high-speed computer. Although the investigation so far has been concerned with the literature of chemistry, an attempt has been made to develop principles broad enough to include other engineering and scientific categories. The system consists essentially of four parts : (1) A data-assembly and data-checking routine for the complete disclosure file of information to be searched ; (2) a data preparation routine for the question to be asked of the file ; (3) the search routine itself, with all of its included subroutines ; and (4) the " checkout " routine, which evaluates the apparent answers found to questions. At the present time, the system requires that a technically trained person read and analyse each document, and that he designate the portions to be coded for the automatic search.

Before an American patent application is

Fig. 13—Patch board being wired for problem on N.B.S. analog computer

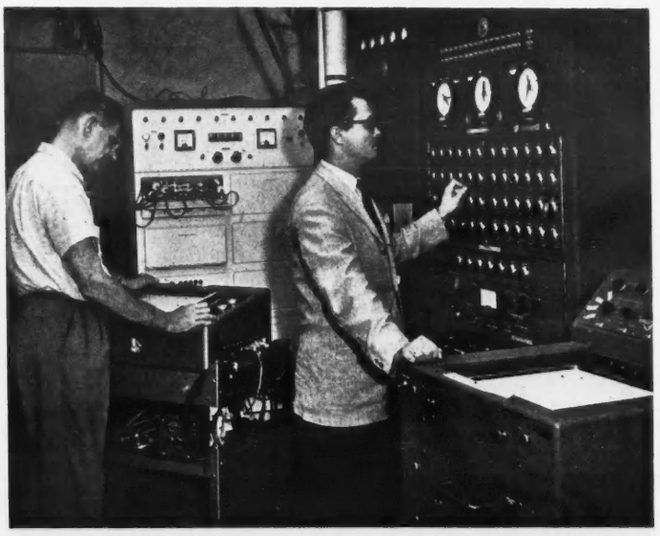


Fig. 14—N.B.S. analog computer with *X-Y* function generator and plotter

THE AMERICAN SCENE *(Continued)*

coded for searching, it must be inspected closely to determine how much and what kinds of information it contains, and to evaluate the relative importance of the various pieces of information. The information in a disclosure on chemistry is arranged in a hierarchy of relationships. The largest segment treated is a complete chemical process with all of its disclosed steps. The next largest segment is a composition or admixture. Each composition is subdivided into groups of ingredients, with groups represented by numerical codes. The individual units within such a group are called descriptors, and may represent such items as individual atoms or bonds or substructures containing a number of different kinds of atoms.

Typical of the questions which were asked in the first generalised pilot programme is the following : " Find a disclosure of a nonaqueous composition, for use against fever and ague, comprising bone-set ; an alkylated cyclohexenyl hydrocarbon containing at least seven carbon atoms and one double bond ; an acyclic ketone consisting of eleven carbon atoms, one oxygen atom and one double bond ; a member of the group consisting of quinine and cinchonidine ; and as a flavouring agent, an extract of the family pinaceae containing an alkylated cyclohexenyl alcohol containing at least one hydrogen atom, one oxygen atom, ten carbon atoms, and one double bond."

The search routine is in one sense a monitor or supervisory routine, which selects a search path after looking into the nature of the question being asked and the characteristics of the document being searched. This routine is a kind of assembly programme for the required sub-routines, where some of the sub-routines are greater than the entire search routine itself. Test runs of the general programme revealed certain inadequacies in the description of chemical compounds ; therefore a very large detailed programme for tracing the topology of functional groupings of structures within the compound was planned and executed.

Included in this topological tracing sub-routine are several relatively sophisticated concepts. Of great concern to a patent examiner is the need to ask a search question generically. Two provisions for doing this are incorporated in the topological tracing sub-routine ; one makes it possible to ask for a genus and to accept as an answer any specific member of the genus ; the other takes into account the problem of the structural " Markush group." By " Markush group " is meant a synthetic genus whose scope is determined by listing all of its members. Thus a single structural entity may define an entire class of compounds by showing a fixed nucleus with various alternate constituents listed at particular points in its topological diagram. It is possible to specify for a Markush group that in addition to acceptance of any one of the listed members of the group, the programme will be satisfied with " no substituent " for that connection.

To carry out the tracing, a basic vocabulary was devised of functional groups within the whole chemical structure ; the data to be handled consist of a listing of all such groups, together with their connective relationships to each other, including the bond types. Several screens are employed to eliminate in certain cases the topological tracing. In the data making up one screen, all terms are listed that represent combinations of chemical significance found in the structure. These terms are made up of at least two functional groups in the topological section and their definitions are fixed and constant. In another screen, generic concepts found in the structure are listed and, where required, defined in terms of the specific functional groups pertinent to the structures under consideration. By referring to these two listings, the programme by-passes many unrewarding searches. In the topological tracing, as like groups are found, or matched, a table of equivalences is set up of the question groups and of the matching groups actually answering the question. Normally, merely the document number is given by the programme as a reference, but in certain complex cases, this " Equivalence Table," which lists all successful matches, can be printed out in its entirety. As it is possible to follow a false trail for a short distance, the programme provides for backing up and looking for a rematch.

The most recent work in the " HAYSTAQ " system has been concerned with the programming of an automatic data-assembly and data-checking routine for the topological tracing programme, and the compilation of a large experimental test file. By trying a variety of test questions against the file, it will be possible to gather some meaningful statistics pointing toward the most profitable directions for future research in information retrieval.

Quality Control of Concrete

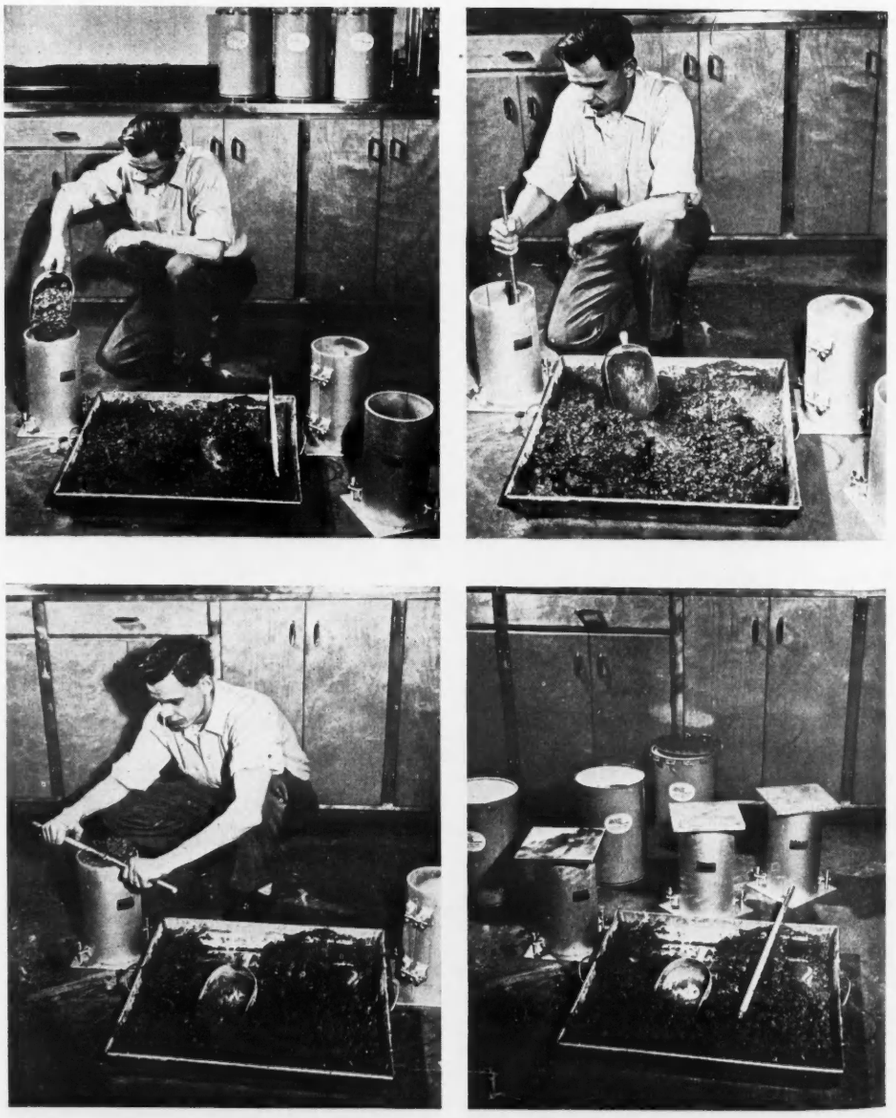
In an attempt to reduce the scatter encountered in testing the seven-day and twenty-eight-day compressive strength of concrete, Soiltest, Inc., 4711, W. North Avenue, Chicago 39, has evolved a controlled procedure for preparing specimens. The specimens are cylindrical rather than cubic, and are divided along a generator to allow the casting to be withdrawn. The new procedure is portrayed in the accompanying illustrations.

Concrete compression test specimens are usually cylindrical with a length equal to twice the diameter. The standard size is 6in in diameter and 12in in length if the coarse aggregate does not exceed 2in in nominal size. Soiltest moulds (upper left) for these test specimens are of metal and have a machined metal baseplate.

(Upper right) The specimens are formed by placing the concrete in the mould in three layers. Each layer is uniformly rodded with twenty-five strokes of the tamping rod.

(Lower left). Where voids are left by the tamping rod, the sides of the mould are tapped to fill the voids. After the top layer has been rodded, the surface of the concrete is struck off with a tamping rod or straight-edge. Test specifications are covered in ASTM C-31 and AASHO T-23.

(Lower right). Specimens are covered with a glass or metal plate to prevent evaporation. They are removed from the mould at the end of twenty-four hours and stored under moist conditions. In the field special Soiltest curing cans are frequently used for storage and curing.



Stages in preparing cylindrical specimen

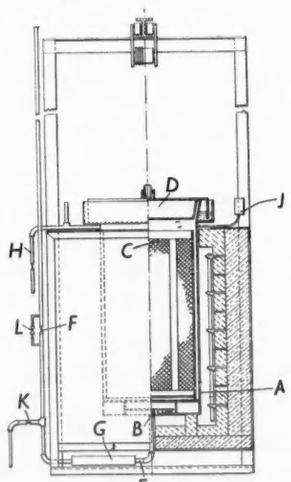
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

METALLURGY

843,395. January 2, 1958.—HEAT-TREATMENT OF METAL PARTS, Hedin, Ltd., Commerce Estate, South Woodford, London, E.18. (*Inventor : James Royce.*)

According to the invention, quenching of the metal articles is carried out in the furnace in which they have been heated by introducing a cooling liquid into the furnace when the heating operation is completed. When the gaseous state of the quenching liquid is suitable for use as the asmosphere for the articles during heating (for example when water is used for quenching and steam for the atmosphere), a small amount of the liquid may be permitted to remain in the heating chamber after a quenching operation, in readiness for the next operation, or may be permitted to enter the furnace during a heating operation. This liquid is then vaporised by the heat of the furnace itself or by a separate heater to provide the required atmosphere. The apparatus shown is for the treatment of non-ferrous metals using water as the quenching liquid and superheated steam as the protective atmosphere. The furnace is supported in a frame and a container *A* of nickel-chrome alloy or heat-resisting steel, spaced from the sides of the heating chamber, is supported on a ring of refractory material. The container has in its base a central aperture *B* for the entry of the quenching liquid. In the base of the container there is a diffuser consisting of a metal plate supported on a ring of perforated material and a perforated plate extending across the whole width of the container. With this arrangement, when the water enters the aperture *B* it is deflected through the holes in the ring and then rises up the container through the perforations in the plate. The perforated plate supports a basket *C* with sides of expanded metal for the metal articles to be treated. The lid *D* of the container has a downturned lip which is located in an annular channel at the top of the container. This channel contains a seal to prevent the escape of gases from the container. A winch enables the basket to be raised and lowered into the container. An inlet pipe *E*, connected with the aperture in the base of the container



No. 843,395

is connected through a valve *F* with a pipe leading to a supply tank (not shown). A bypass valve *L*, arranged in parallel with the valve *F*, permits a small flow of water during the heating operation. An auxiliary heating element *G* on the inlet pipe close to its point of entry into the furnace is used to heat the quenching liquid when it is vaporised to provide the protective atmosphere in the furnace. The container is also provided with an overflow pipe *H* and a steam outlet. A pyrometer *J* indicates the temperature in the furnace. When a loaded basket has been placed in the container, the control valve is adjusted to permit a small flow of water through the inlet pipe and current is supplied to the furnace heating elements and to the auxiliary heater. The valve *F* and drain valve *K* are closed at this time. When the heating of the metal articles is completed the valve *F* is opened causing a flow of water into the container to quench the articles in the basket. After the quenching operation the valves *F* and *L* are closed and the drain valve *K* is opened to permit the removal of the water from the container. In an alternative form of the apparatus, the overflow pipe *H* and steam outlet above it may be replaced by an overflow pipe incorporating a pressure regulator and a pressure indicator. In this way a pressure may be built up in the container to obtain an atmosphere more suitable for some metals. As an example, a pressure of 5 lb per square inch has been found suitable for the heat-treatment of non-ferrous metals. In another alternative form of the apparatus a recess or pocket can be formed in the container to enable a part of the water to be left behind when the valve *K* is opened. This water serves to create the protective steam atmosphere during the next heating operation. If ferrous metals are to be treated a further inlet may be provided in the container to enable an appropriate protective gas to be introduced during the heating operation. Alternatively, a pocket in the container may be filled with oil before the heating operation to provide the required atmosphere.—*August* 4, 1960.

ROADWAYS

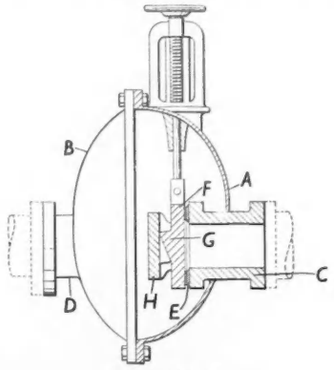
841,568. August 12, 1957.—EXPANSION JOINTS FOR BRIDGE AND LIKE ROADWAYS, Vernon Ferdinand Bartlett, James Kenneth Anderson, and Jasper Kell (trading as Mott, Hay and Anderson, of 9, Iddesleigh House, Caxton Street, London, S.W.1.). (*Inventors : Alan Edward Spence Temple and David William Smith.*)

In large bridges considerable expansion takes place due to changes of temperature, and where a roadway for vehicles or foot passengers is supported by longitudinal girders which are free to expand and contract, it is necessary to allow for the expansion and contraction by sliding joints which maintain the continuity of the surface under all conditions. The usual method is to have two horizontal comb-members which form part of the road surface, the two sets of prongs interfitting so that they can slide one between the other and maintain continuity of surface. This arrangement is open to objection because it is liable to freeze up and interfere with free expansion ; it also allows water to drop through on to bridge structure, causing corrosion, and is liable to be clogged by dirt. According to the invention an expansion joint for a roadway for the purpose described consists of a number of metal plates set on edge and extending across the roadway. The plates are intercalated with cushions of rubber and supported on beams spanning the gap between the portions of the roadway. Preferably the plates are bonded to the rubber cushions, which extend along their whole length. Preferably, the assembly of plates and cushions is maintained under compression even when the joint is at its maximum degree of expansion. In this way a watertight seal is maintained right across the joint and water can be drained into appropriate gutters at the sides. The specification illustrates by way of example one particular construction of expansion joint in accordance with the invention.—*July* 20, 1960.

VALVES

843,101. February 7, 1957.—VALVES FOR CONTROLLING FLUID FLOW, The Power-Gas Corporation, Ltd., Parkfield Works, Stockton-on-Tees, County Durham. (*Inventor : William McInnes.*)

The invention relates to valves for controlling and regulating the flow of fluids and is especially applicable to large size stop valves. An object of the invention is to provide a valve in which distortion of the seat relative to the closure member is substantially reduced when the valve is subjected to varying temperatures and/or pressures. In the embodiment illustrated, a stop valve comprises two torrispherical or bowl-shaped members *A* and *B* detachably connected together by bolts, to form a valve casing. These members carry an outlet connection *C* and an inlet connection *D* substantially in axial alignment. A valve seat *E* in the form of a machined ring is welded to a flange at the inner end of the outlet connection. A valve disc *F* carries a machined ring on its surface facing the connection *C* and is connected to a valve operating rod which passes through a stuffing-box, and connects with a suitable operating mechanism outside the valve casing. The valve disc has a wedge-shaped projection *G* extending from its other surface for engagement with a corresponding wedge piece extending from a bridge member *H* secured to the connection member and extending across its opening at the side of the valve disc. The valve disc is illustrated in a closing position in which the wedge portions are in engagement so as to thrust the valve disc towards the connection member and promote a tight joint between the valve seat and the ring. The torrispherical or bowl-shaped members are of fabricated metal plate which is sufficiently elastic that the two members form a valve casing in



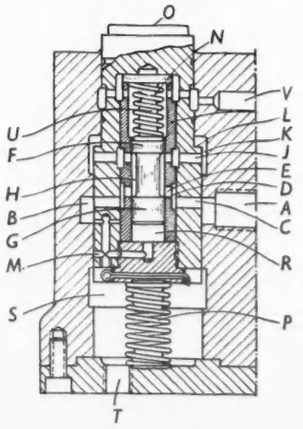
No. 843,101

which any stresses set up are substantially uniformly distributed. The bowl members are each shaped approximately as a segment of an ellipsoid. Any stresses set up in the casing such as by fluid when the valve is in use are substantially uniformly distributed, thereby reducing the liability for distortion to arise between the valve seat and disc.—*August* 4, 1960.

MOULDING MACHINES

844,521. December, 12, 1956.—VIBRATORY APPARATUS, Inge Troost-Blecher and Walther Romunter, Partners of Rittershaus and Blecher, 16-18, Besenbruchstrasse, Wuppertal-Barmen, Germany.

The invention relates to vibratory apparatus having a fluid-pressure-operated reciprocating piston, particularly for use for jolt ramming moulding machines. Its object is to provide a vibratory apparatus having a continuously reciprocating working piston and which can be adapted to be used as an independent vibrator or as a component part of a machine. The



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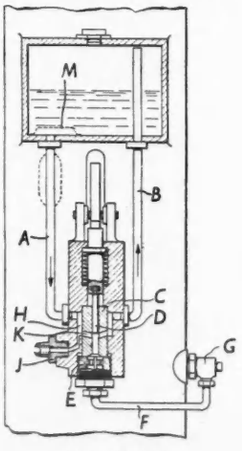
mode of operation of the apparatus can be followed from the drawing. The position of the elements of the apparatus as shown is taken as a starting point. In this position the pressure fluid can pass through the passage *A*, annular chamber *B*, transverse bores *C*, annular chamber *D*, and bores *E* into the space lying between the control surfaces provided by the shoulders *F* and *G* of the control piston *H* and from there out through transverse bores *J* into an annular pressure chamber *K*. The pressure fluid cannot escape from this chamber. In the region of the pressure chamber *K* the piston has a shoulder *L*. Simultaneously with the flow of pressure fluid as above, fluid also passes through the passage *A* and bores *M* into a chamber *R* beneath the shoulder *G*

of the control piston. The fluid accumulating in this chamber at first prevents downward movement of the control piston by the action of the spring *N* loading it. When the pressure in the chamber *K* increases owing to the continuing flow of fluid, the working piston *O* is subjected to a force which is exerted on the shoulder *L* and the magnitude of which depends on the area of the shoulder so that the piston is moved inwardly against the spring *P* which is compressed. On the commencement of this movement the supply of the pressure fluid to the chamber *R* is first broken, because the bores *M* no longer communicate with the annular chamber *B*. However, the cushion of fluid locked in chamber *R* cannot escape, so that the control piston *H* is moved jointly with the piston *O*. The greater the amount of fluid introduced into the pressure chamber *K*, the more the piston *O* is moved inwardly and the more the spring *P* is compressed. At the instant when the transverse bore *M* slides over an exhaust chamber *S*, the fluid in the chamber *R* can escape into the exhaust chamber through the bores *M* and from there through the outlet *T* into a reservoir. The force opposing the spring *N* is thus eliminated. The spring now expands and, pushes the control piston *N* in. On this movement, the control surface *F* of the control piston opens the transverse bores *J* to an outlet chamber *U* and the fluid in the pressure chamber *K* can escape through bores into the outlet *V* and from there can flow back into the reservoir. The fluid pressure exerted on the working piston *O* is thus eliminated and the spring *P* can become operative to push the piston upwards, until the position shown is reached, where the pressure fluid can flow again into the pressure chamber *K* and into the chamber *R*, whereby the cycle begins again. It is stated that the number of strokes or vibrations of the apparatus according to the invention can be of the order of 4000 per minute.—*August* 10, 1960.

PILE DRIVERS

844,027. January 30, 1959.—Diesel Ram for Pile-Drivers, Reinhold Dornfeld and Eberhard Dornfel trading as Delmag-Maschinenfabrik Reinhold Dornfeld, Esslingen am Neckar, Germany.

In damp and cold weather, pile driver rams operated as diesel engines are generally slow in starting and according to this invention starting is facilitated with a diesel ram which includes ducts for ordinary fuel and a valve controlled duct for starting fuel extending into the lower part of the pump chamber. Means for passing starting fuel under pressure through the duct into the lower part of the chamber forces the ordinary fuel in the lower part of the pump



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chamber back towards the main tank. After starting fuel has been forced in, pure starting fuel, or a mixture containing a high proportion of starting fuel, is injected during the first few strokes by the normal injection pump. The ram is, therefore, started with pure, or substantially pure, starting fuel, and then with a mixture which at first contains a high, gradually decreasing amount of starting fuel, until, when the ram has warmed up, ordinary fuel is drawn-in by the pump. A sectional elevation of one construction according to the invention is illustrated by way of example. In the accompanying drawing only the part of a ram cylinder is shown. A fuel tank for ordinary diesel fuel and an injection pump are secured to the cylinder. The pump is connected to the fuel tank by a feed duct *A* and by a breather pipe *B*. The injection pump contains, in known manner, the pump cylinder *C* and the piston *D*, together with the piston-driving means generally provided, a detailed description of which is unnecessary. The pressure space of the pump cylinder is connected through a member *E* and a duct *F* to the injection nozzle *G* in the cylinder of the ram. The feed duct *A* is connected to the pressure space of the pump cylinder through the pump chamber *H* and a duct *K* extending through the cylinder. At the base of the cylinder block of the injection pump there is a boss through which an inlet for the starting fuel formed as a charging nipple *J* is introduced. The charging nipple which contains a backpressure or relief valve constructed as a spring-loaded ball, is connected to the pump chamber. To enable starting in cold weather, a suitable device, such as a hand-operated starter, forces the starting fuel into the pump chamber connected to the charging nipple. When the adequate quantity of starting fuel has been injected, the ordinary fuel in the feed duct *A* is forced back, in some cases even as far as to the connection to the tank.—*August* 10, 1960.

ELECTRICAL ENGINEERING

844,234. February 25, 1958.—Automatic Control of Lifts, Allmanna Svenska Elektriska Aktiebolaget, Vasteras, Sweden.

The present invention relates to an arrangement for controlling the retardation of lifts and mining hoists of the kind in which the driving means is influenced by an automatically-acting speed regulator which compares a speed-dependent voltage, taken from a tachometer generator, with a reference voltage. In such a scheme, if the reference voltage is taken from a potentiometer, the movable contact of which has been mechanically coupled to the driving means during the retardation period, the contact must be returned to its initial position before the next retardation can begin. In accordance with this invention, however, first and second reference voltages are derived from two mechanically interconnected reference voltage transmitters arranged to be coupled mechanically to the driving means of the car, during the retardation period. The output voltages of the reference voltage transmitters are functions of the position of the lift car in the shaft and are arranged so that as the first reference voltage is being reduced, the second is being increased, this second voltage being a maximum when a retarding action depending on the first reference voltage is completed. The two reference voltage transmitters may be combined into a single potentiometer having two rotatable contacts diametrically arranged in respect to each other. This combined potentiometer can be coupled to the driving means of the lift car by an electromagnetic clutch which is engaged when the car passes floor contacts. The potentiometer contact arm then decreases the reference voltage, which at a certain point becomes less than that from the tachogenerator on the driving shaft, allowing a diode to conduct so that current passes through the brake solenoid. Before the brake finally engages, limit contacts in the potentiometer device have disengaged the engaged destination contacts in the floor selector so that the magnetic clutch is also disengaged. During retardation the sliding contact in the potentiometer has moved half a turn, but the diametrically opposed contact has moved similarly and is now in position for a further retardation. In order for it to become effective, it must be brought into circuit by a change-over switch. This operation can be performed by means of relays controlled by limit contacts in the potentiometer or by other means.—*August* 10, 1960.

844,366. November 15, 1955.—Contact Systems for Air-Break Circuit Breakers, The English Electric Company, Ltd., Queens House, 28, Kingsway, London, W.C.2. (*Inventor : William John Joyce.*)

This invention relates to contact systems of air-break electric circuit breakers of the kind in which a single movable contact is arranged to bridge two fixed contacts. A single movable contact is arranged to bridge two fixed contacts disposed on opposite sides of its axis of travel, the movable contact comprising a contact ring which is arranged to rotate about its central axis. The fixed contacts are offset relative to one another in the direction of the axis of travel of the movable contact, and their contacting surfaces are mutually inclined. Therefore, upon closure of the contacts, the moving contact ring engages one fixed contact before the other and is thereby caused to turn slightly about its axis each time the circuit breaker contacts close, thus promoting an even wear of the contact surfaces on the ring. In the example shown in the specification, a typical value of the offset of the fixed contacts required in a circuit breaker having a 4in diameter movable contact ring is $\frac{1}{16}$in in the direction of contact movement. A peripheral displacement of the contact ring by about $\frac{1}{4}$in is obtained each time the circuit breaker operates. Whereas, in the embodiment shown, the ring is resiliently supported by means of a rubber bush, it is within the scope of the invention to have it supported by, for example, radially-acting helical springs which are arranged between a pivoted collar and the ring.—*August* 10, 1960.

Catalogues and Brochures

A. A. Jones and Shipman, Ltd., Narborough Road South, Leicester.—List No. 264 giving details of "Lamalock" collet chucks.

W. E. Sykes, Ltd., Staines, Middlesex.—Publication No. P13/60 containing technical details of the model "HV14A" universal hobbing machine.

Victor Products (Wallsend), Ltd., G.P.O. Box No. 10, Wallsend-on-Tyne.—Technical bulletin No. 39 describing a miniature fluorescent bulkhead lighting fitting.

Johnson and Phillips, Ltd., Charlton, London, S.E.7.—Illustrated leaflet describing the type "D" fuse-switch used for the protection of overhead distribution systems, for operation at all current values up to 8000A at 11kV.

Communication Systems, Ltd., Norfolk House, Norfolk Street, London, W.C.2.—Leaflet describing the A.T.E. intercom. loudspeaking master station. This type of loudspeaker is available for ten-way, fifteen-way and twenty-way systems.

Associated Electrical Industries (Rugby), Ltd., Rugby.—Publication (SP.3855-71) entitled "Machine Tool Drives," containing the results of development and investigation into the requirements of electrical drives for, and control of, machine tools, including automatic control systems for machines of all types.

Pilkington Brothers, Ltd., St. Helens, Lancashire.—"Daylight with Insulation," by Thomas A. Markus, deals with windows, and ways of improving their performance. Sections in the booklet cover heat transfer, humidity, sound insulation ; daylight and economics. Tables of symbols and units are included together with conversion factors.

Climax Molybdenum Company of Europe, Ltd., 2, Cavendish Place, London, W.1.—Manual entitled "Atlas : Hardenability of Carburised Steels," containing data on hardenability of carburised steels as measured by the company's Detroit Research Laboratory in a programme continuously pursued since 1951. Information in the manual, which is entirely of American origin, is given in the form of Jominy hardenability curves.

Associated Electrical Industries, Ltd., Aircraft Equipment Group, Rugby.—A sixty-four page brochure dealing with aircraft equipment, covering a.c. and d.c. power systems, ignition equipment, control, starting gear, and power generation and utilisation equipment. A section is included devoted to electronic ignition testers, electronic leak detectors, semiconductor rectifiers, mobile test sets, public address equipment, and lamps and lighting.

The Siemens and General Electric Railway Signal Company, Ltd., East Lane, Wembley, Middlesex.—Illustrated booklet, RS 68, No. 2 in the series "Signalling Installations for British Railways," describing schemes carried out by the company at Huddersfield, N.E. Region ; on the Colchester-Clacton-Walton 25kV electrified lines of the Eastern Region ; and on the Farningham Road to Sittingbourne section of the Southern Region 750V d.c. electrification to the Kent Coast, including the electronic C.T.C. equipment on the Sheerness branch. A folding diagram shows the layout of the signalling at Huddersfield.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Fri., Sept. 2.—Liverpool and District Branch : Industrial Development Centre, M.A.N.W.E.B., Paradise Street, Liverpool, 1, Chairman's Address, L. Harper, 7.30 p.m.

BIRMINGHAM SCIENCE MUSEUM

Thurs., Sept. 29.—Museum of Science and Industry, Newhall Street, Birmingham, 3, "Live Steam Operation of Five Engines," evening until 9 p.m., additional to regular "Steam Week-ends."

BRITISH INTERPLANETARY SOCIETY

Thurs., Sept. 1.—Manson House, 26, Portland Place, London, W.1, One-day Joint Symposium, with the Society of Instrument Technology, on "Rocket and Satellite Instrumentation," 10.30 a.m.

Mon., Sept. 12.—Lancaster Room, Caxton Hall, London, S.W.1, "Spaceflight—Hints, Pitfalls and Problems," L. J. Carter, 7 p.m.

Tues., Sept. 13.—Lancaster Room, Caxton Hall, London, S.W.1, "Special Points in Lectures to Schools," N. H. Langton, "Preparing a Technical Paper," L. R. Shepherd, 7 p.m.

INSTITUTION OF PLANT ENGINEERS

Tues., Sept. 6.—London Branch : Royal Society of Arts, John Adam Street, Adelphi, Strand, London, W.C.2, "Pneumatic Transfer Machinery and Circuitry," D. C. Evans, 7 p.m.

Wed., Sept. 7.—Edinburgh Branch : 25, Charlotte Square, Edinburgh, "The History of Boilers," W. Renton, and "An Engineer and the Carpet Industry," W. Geekie, 7 p.m. ★Leicester Branch : Saracen's Head Hotel, Leicester, Film and Discussion "On Schedule," F. W. L. Heathcote, 7 p.m.

Thurs., Sept. 8.—Glasgow Branch : Scottish Building Centre, 425, Sauchiehall Street, Glasgow, "Factory Fire Alarm Systems," W. Roby, and R. S. C. Dougall, 7.15 p.m. ★North East Branch : Roadway House, Oxford Street, Newcastle upon Tyne, 1, "Electrical Power Distribution," J. E. Finn, 7 p.m.

Wed., Sept. 14.—Western Branch : Royal Clarence Hotel, Exeter, "Motorway," film and talk on the construction of the M.1, 7 p.m.

Thurs., Sept. 15.—Blackburn Branch : Castle Hotel, Blackburn, "New Developments in Fuel and Power Technology," M. W. Thring, 7.30 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Tues., Aug. 30 *to Sat., Sept.* 3.—The University College of North Wales, Bangor, Annual Conference, 1960.

NINTH INTERNATIONAL CONGRESS OF PHOTOGRAMMETRY

Sept., 1960.—To be held at the University of London under the auspices of the International Society for Photogrammetry ; Sept. 5 to 16, technical sessions ; Sept. 6 to 16, exhibitions ; Sept. 17 to 21, technical tours.

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This Birlec Adsorption Dryer, model BY900, serves instrument panels controlling boilers for fractionating and distillation processes at BP Refinery, Grangemouth. The dryer, which is fully automatic in operation, keeps air lines free from blockages that could be caused by condensed moisture, rust, and (in cold weather) ice. Compressed air at 120 p.s.i.g. for instrument operation is maintained at an outlet dewpoint of 0°F. Handling flows up to 1500 s.c.f.m., the dryer ensures accurate instrument readings by removing water vapour from the compressed air supply.

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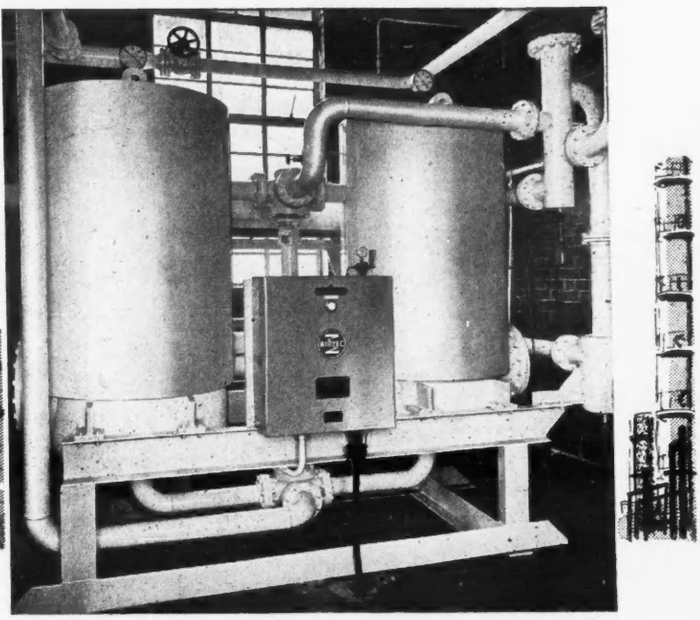

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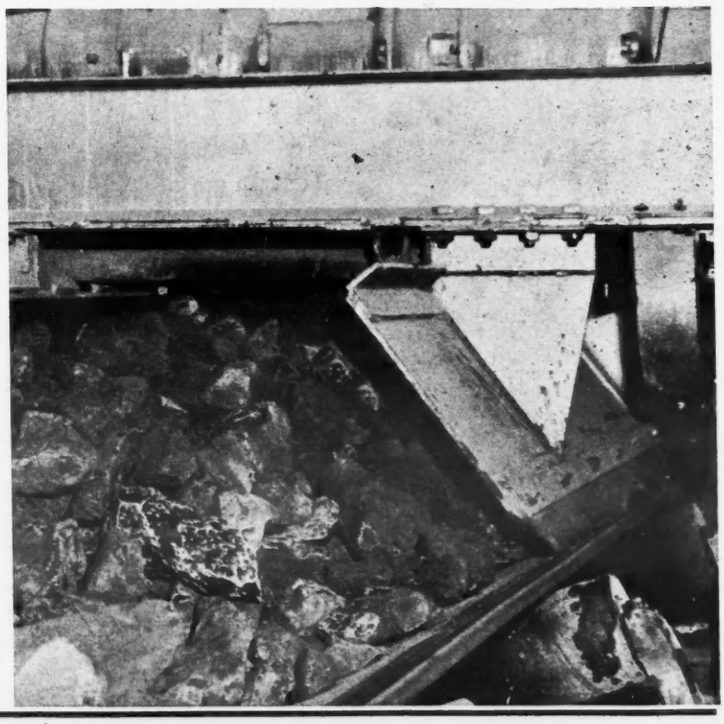

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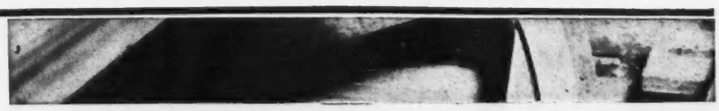

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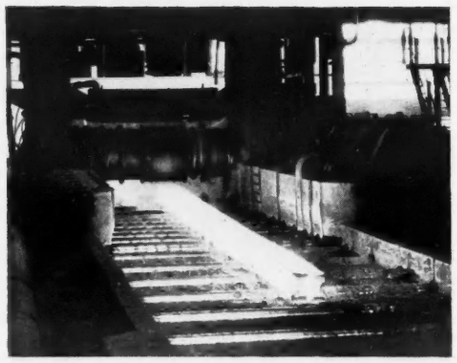

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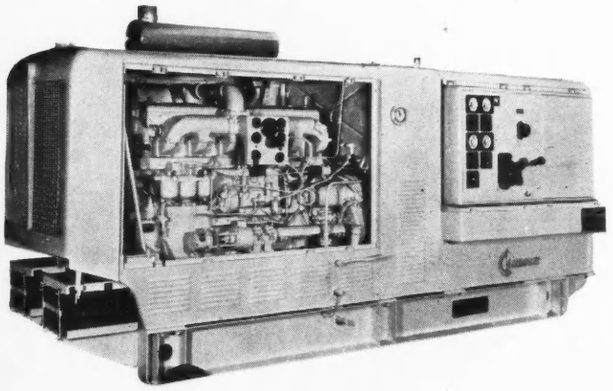

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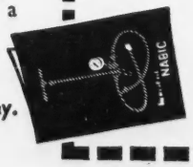

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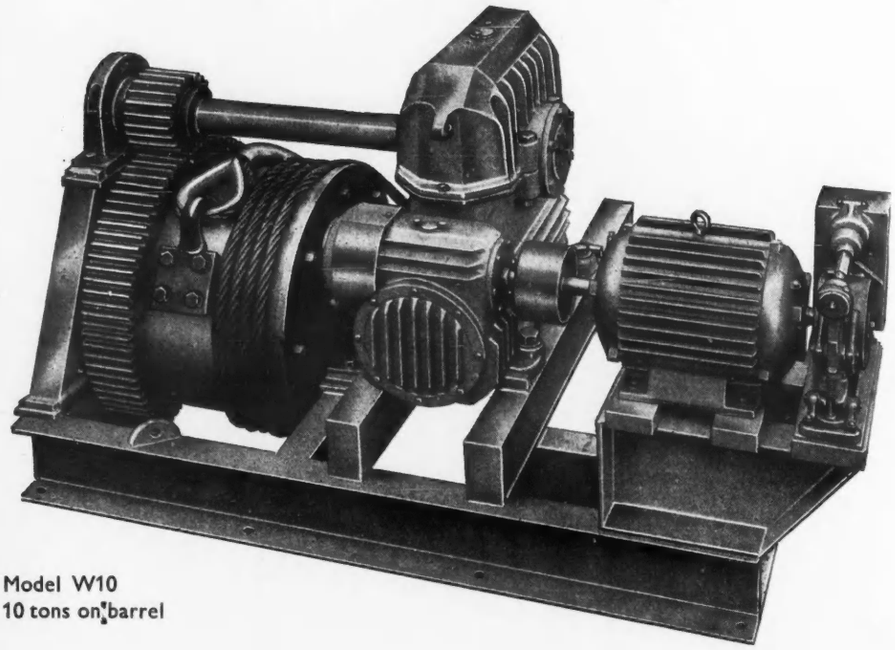

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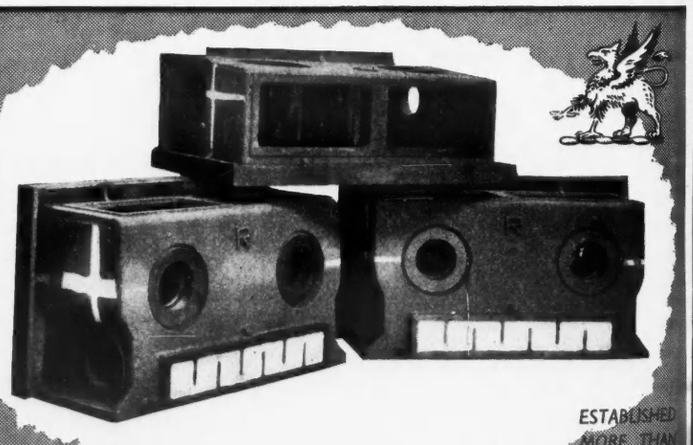

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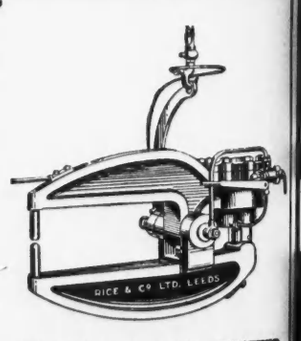

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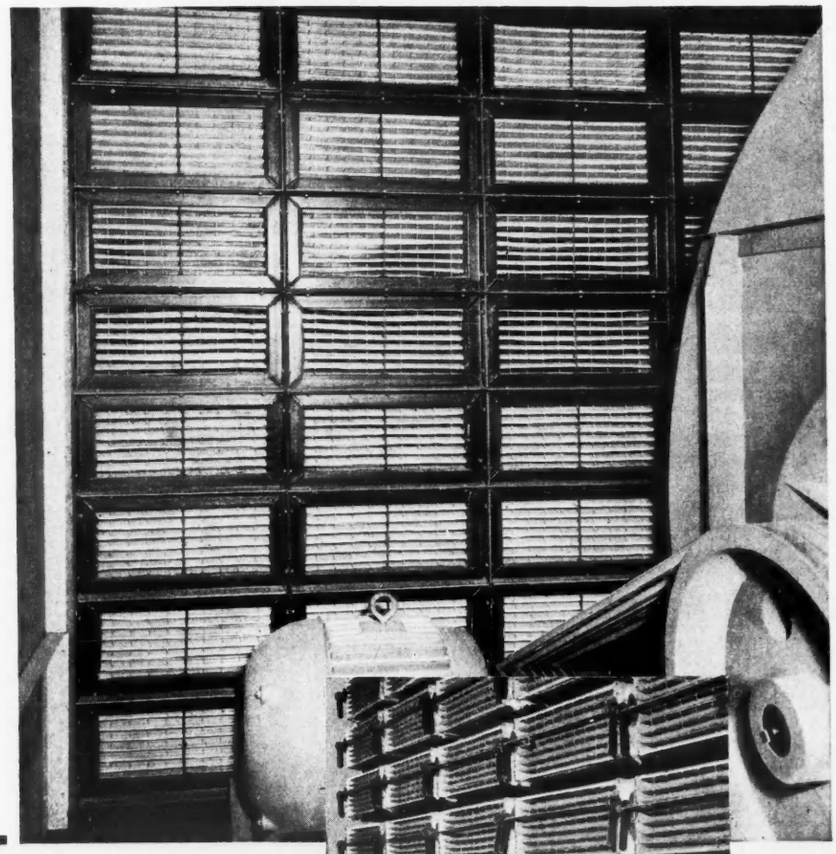
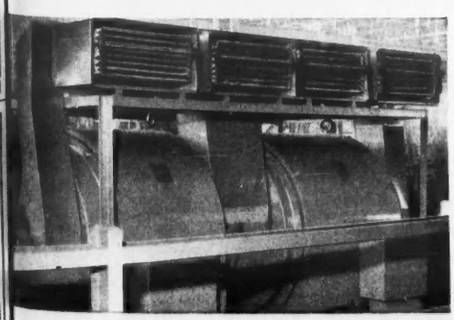
Further proof of the popularity and high efficiency of the Vokes K.600 'Kompak' air filter comes from Kelvinator (Australia) who manufacture domestic and industrial refrigerators. Their problem was to keep dust and dirt out of air supplied to the paint shop. The standard of paint finish on the cabinets is exacting and the high gloss paint used accentuates any dirt defects.

It was decided therefore to install a bank of seventy K.600 'Kompaks' as secondary filters in each of the first and second coat air systems. 'Kompaks' were chosen because of easy maintenance, the facility with which they can be built into banks without any additional framework, and their outstanding performance—a guaranteed efficiency of 99.9% against particles down to five microns in size, and a unit capacity of 600 cu. ft. per minute with initial resistance of 0.15 w.g. at normal rating.

The installation of these filters has proved completely satisfactory; fibrous particles, slagwool and lint are effectively removed from air supplied to the paint shop and it has been found that painting operations can continue even when individual primary filter cells fail owing to short circuits, etc.

The 'Kompaks' require servicing only at long intervals; when replacement of the inexpensive filter medium *does* become necessary it can easily be carried out by unskilled labour.





The illustrations on the right show (above) the clean side and (below) the dirty side of one of the banks of seventy 'Kompaks' used by Kelvinator.

Another application for this widely used low priced air filter. Four Vokes K.600 'Kompaks' giving trouble-free service on Alternators at British Tube Mills in Adelaide, South Australia.

Please write for comprehensive literature on the 'Kompak' and Vokes' other air filters.

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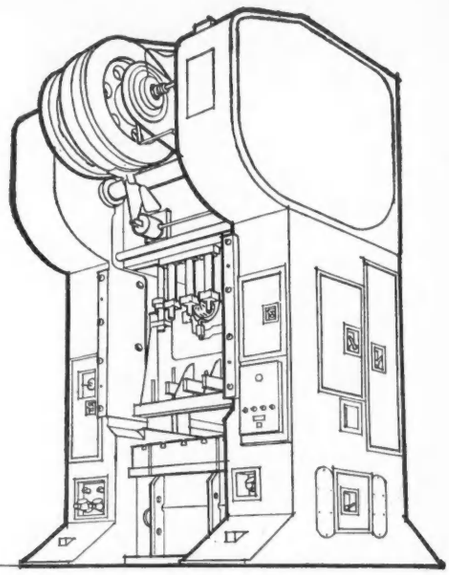

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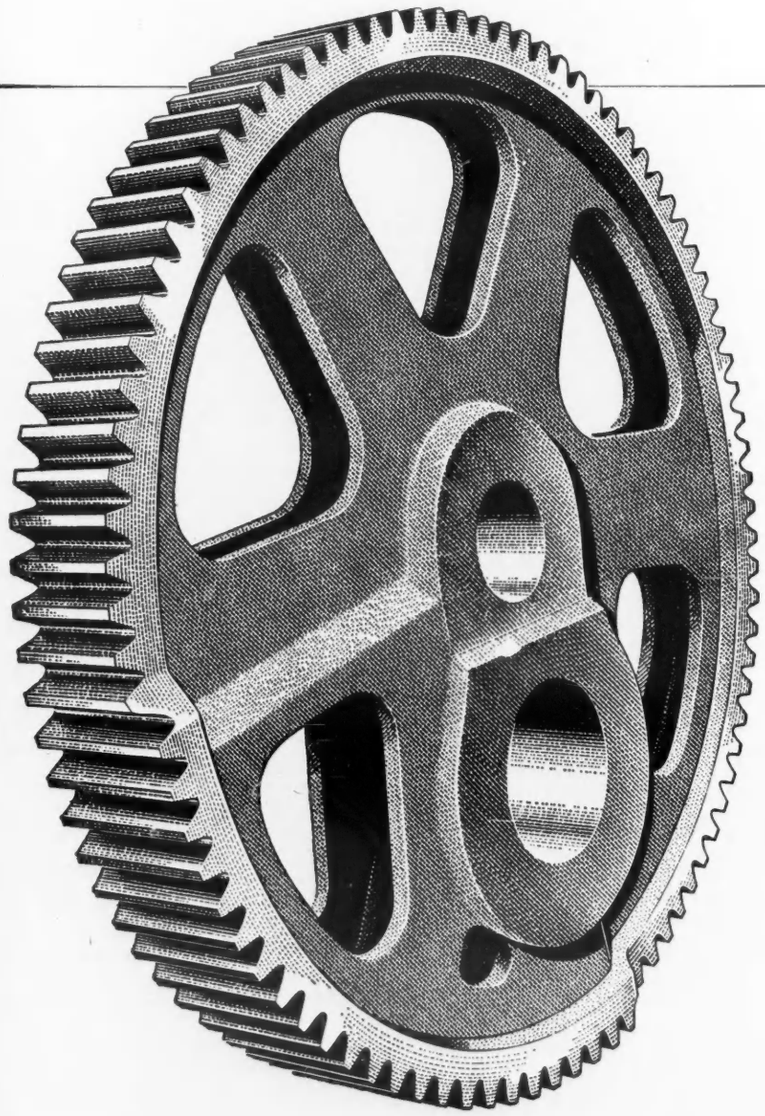

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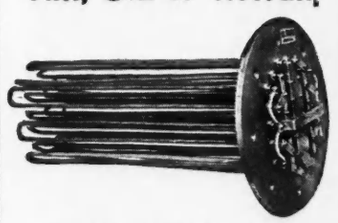

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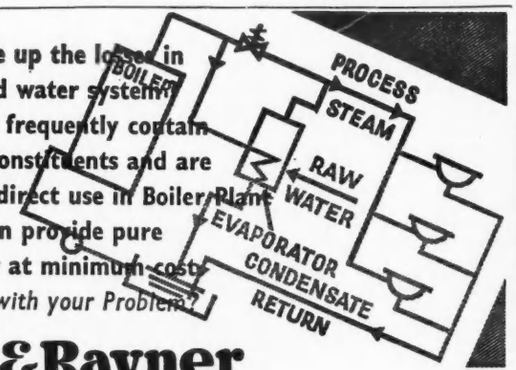

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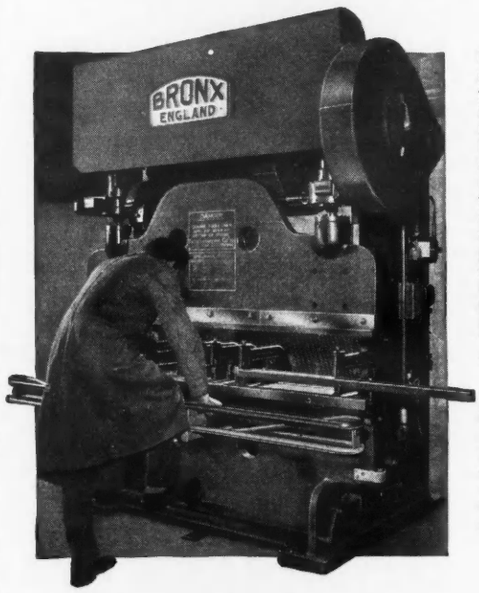

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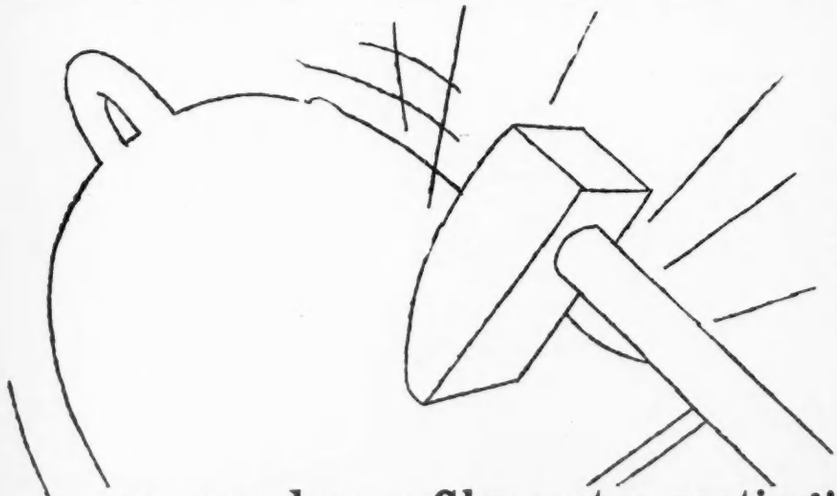

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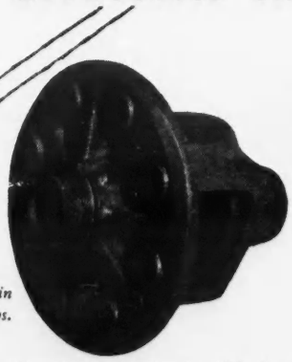

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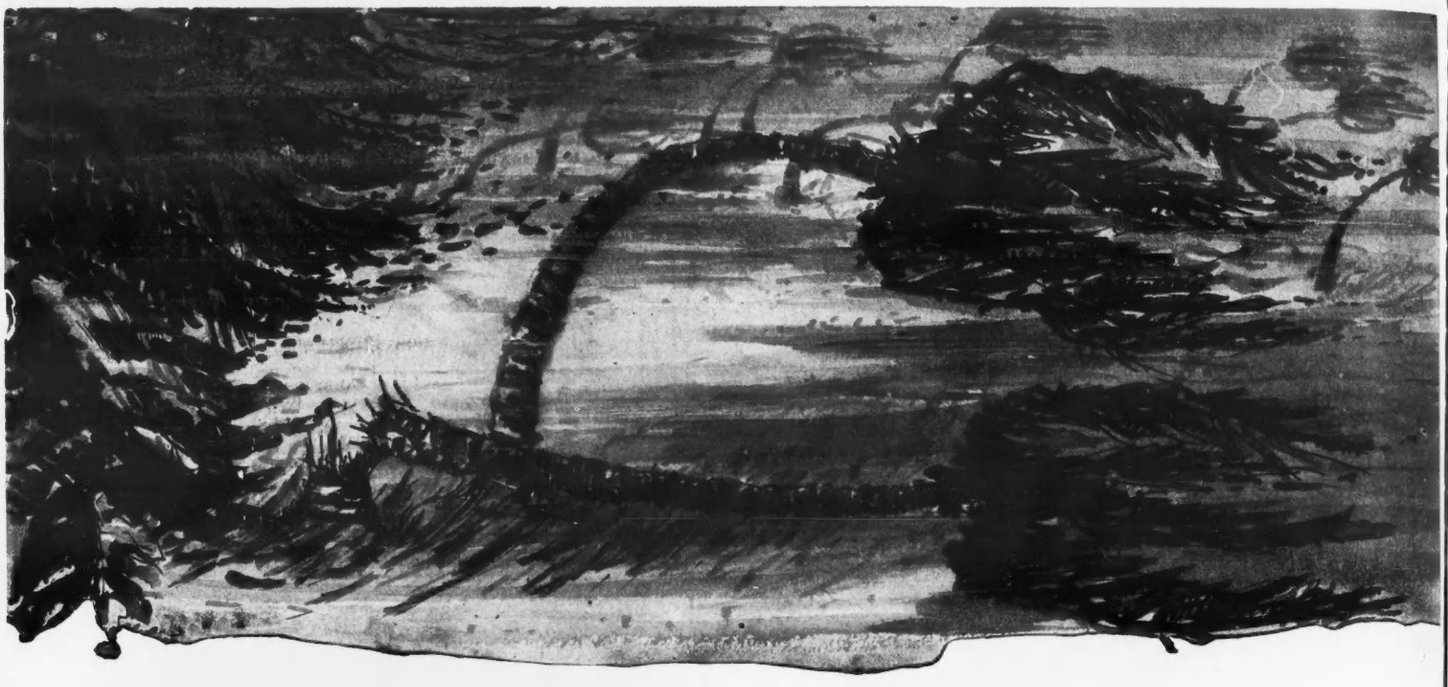

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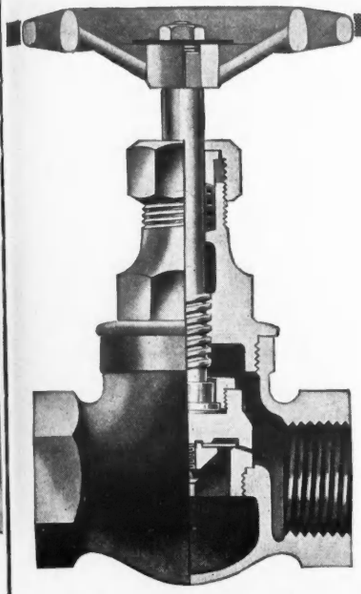


the Fig. 2016 'PRESEATOR' globe valve with the Flexible Titanium Disk*

This specially designed Hattersley valve incorporates a flexible pre-seating disk made of an I.C.I. titanium alloy which is exceptionally resistant to corrosion and erosion. As this seats before the main surfaces, pipe-scale is trapped and the main seating surfaces protected from the effects of wire drawing.

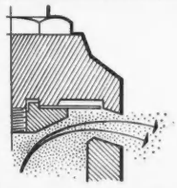
The broad-faced clack and its seat are of differing compositions of nickel alloy, giving differential surface hardness which prevents galling and seizure. There are many other fine features in this new design valve.

Suitable for steam at 200 lb. per sq. in. and 500° F.

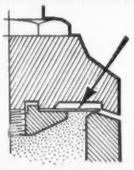
Please write for literature.

* *The Flexible Titanium Disk is protected by Patent No. 822147*

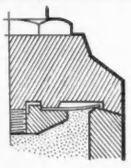
Over a period of years the outstanding merits of this Valve have been proved under the most arduous service conditions on many installations.



In open position free passage for flow directed across seating surfaces.



In 'Pre-shut' position flow and pipe scale held back by *Flexible Titanium Disk.* Patent No. 822147



Valve fully closed. Seating surfaces have passed through wire-drawing zone under virtually 'no-flow' conditions.

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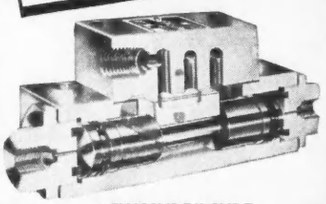
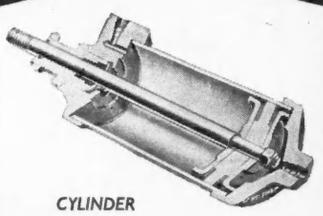
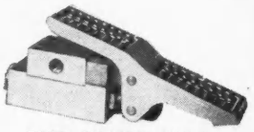


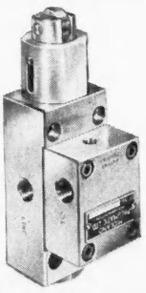
"FLUOSLIDE" SLIDE VALVE



CYLINDER



FOOT CONTROL VALVE



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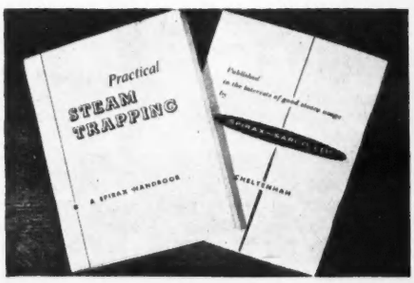
A handful of gold dust

The fact that our new pocket manual "Practical Steam Trapping" has a bright yellow cover doesn't make it worth its weight in gold. But we think its contents might well do so. "Practical Steam Trapping" is a completely new and enlarged version of that old steam user's friend "How to Fit Steam Traps". Like its predecessor, "Practical Steam Trapping" sets out to show that the profitable choice, fitting and use of steam traps repays logical thought. Over a wide field of the more common applications, it recommends first and second choices of trap, and shows how to fit them. A further section describes the whole Spirax range, including the remarkable 'TD', and there's some down-to-earth talk about capacity calculations, lifting condensate and so forth. According to our records, 100,000 people in all parts of the world thought our old "little yellow book" well worth having. On the argument that "Practical Steam Trapping" is better still, you ought perhaps to lose no time in getting yourself or your staff as many copies as you can usefully do with.



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The casting, which is 11 inches diameter and weighs 38 lb., meets the following specification:

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Journal: **induction hardened.**
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Min. yield strength: **80,000 P.S.I.**
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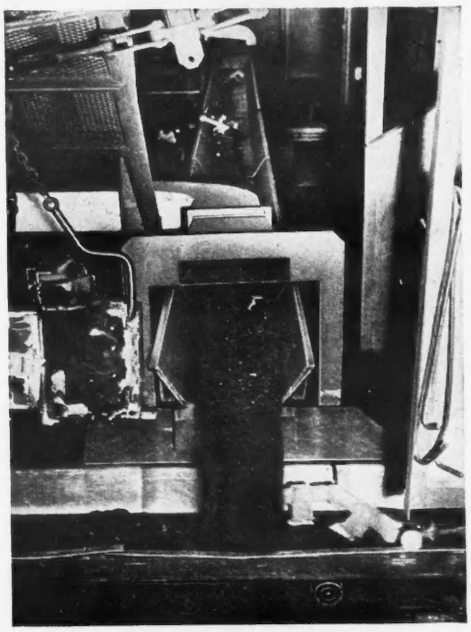
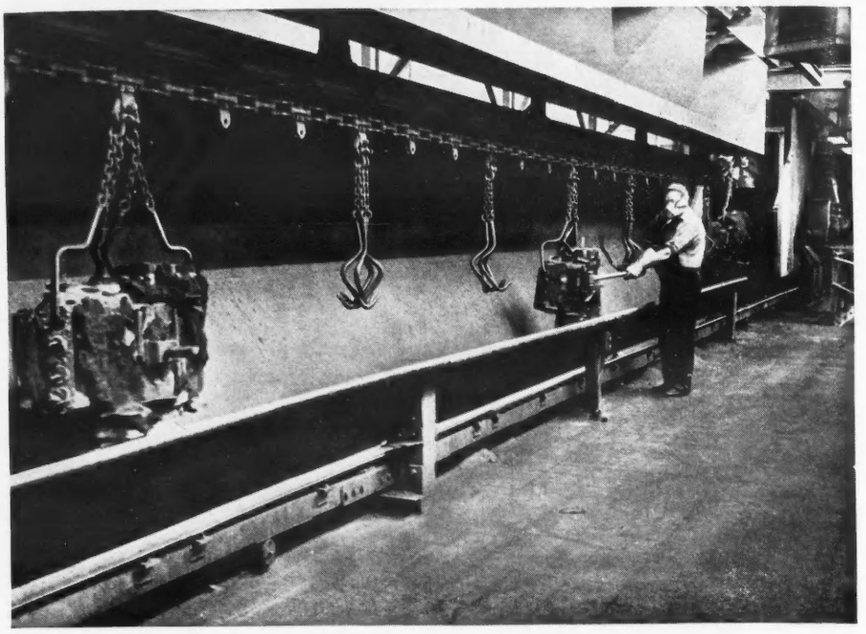
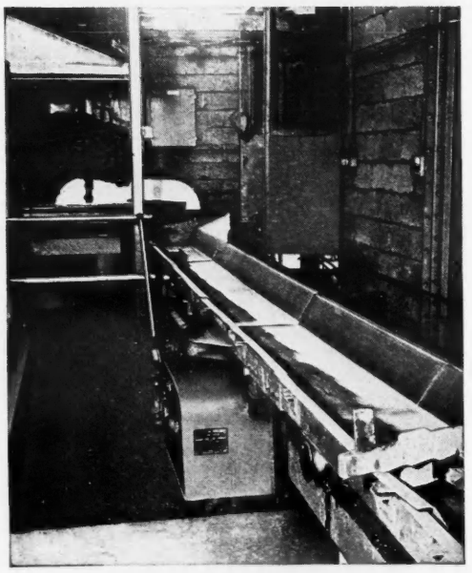


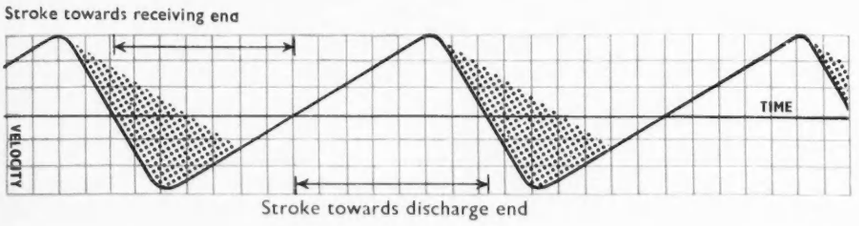
Shaker conveyor discharging scrap on to a similar conveyor.



Sand cores and risers from engine component castings fall on to a shaker conveyor which carries them to a rotary scrap breaker and sand separator.



Shaker conveyor showing type G20 drive, driven by a 20 h.p. flywheel motor; this robust drive delivers high peaks of energy.



SHAKER CONVEYING

in a mechanised foundry

The Distington-Goodman shaker conveyor is not a jigger conveyor. Its troughs move in only one plane on ball-bearing rollers and propel material by variations in their rates of acceleration and deceleration (these are shown in the time-velocity curve above: the shaded areas represent the movement of material independent from the movement of the troughs).

Distington-Goodman shaker conveyors have been used for many years for loading and conveying coal and rock. Their robust all-steel construction makes them ideal for handling hot materials in foundries and cement clinker and sinter.

They are easily extended and contracted and can be made self-loading from stock heaps. Lines of troughing can be made to deviate through angles up to 90°. Conveying capacity depends upon several factors but would normally exceed 60 t.p.h. on the level.

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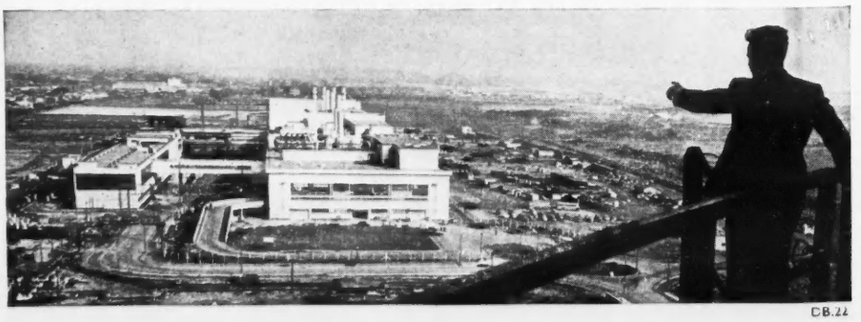

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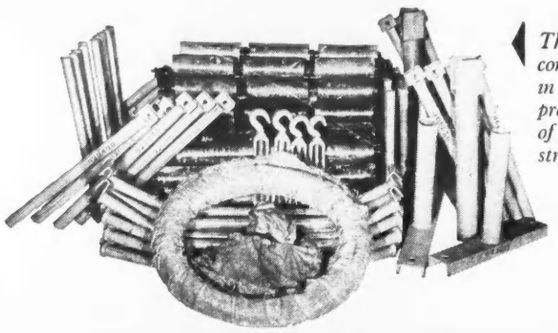
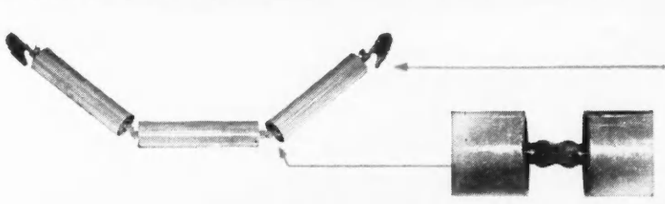


This group of components—stacked in an area of 28 sq. ft.—produce 200 ft. of this conveyor structure . . . .

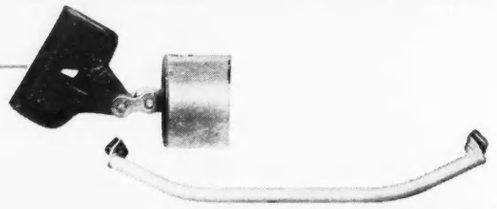
DISTINGTON-GOODMAN

ROPE BELT

CONVEYOR STRUCTURE
patented



swivel links are fitted at each end of an idler shaft

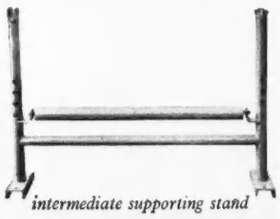


stretchers are used at intervals between stands

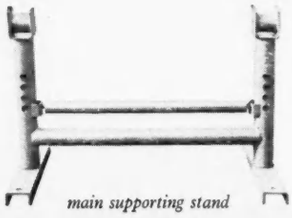
RESILIENT

- *— increases belt life*
- *— reduces installation costs*
- *— increases capacity*
- *— almost eliminates spillage*
- *— inexpensive*

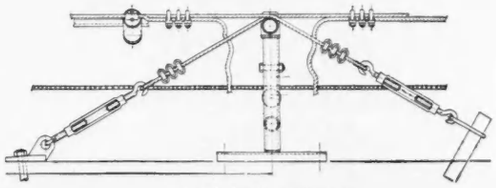
wire rope ¾" dia. and 6 x 19 regular lay



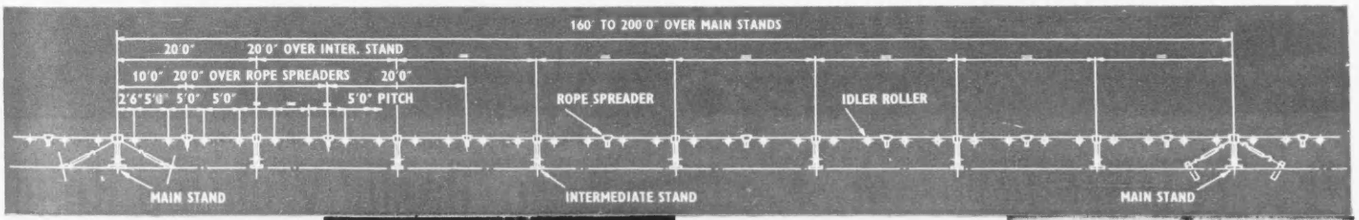
intermediate supporting stand



main supporting stand



typical rope anchorages



Installation, extension and contraction of Distington-Goodman Rope Belt Conveyor Structure is relatively quick and easy.

(Right) Detail of a main stand and anchor point. These can be spaced up to 400' apart according to requirements.

A 36"rope belt conveyor installed at a quarry, carrying 500 tons of gravel per hour. By securing the rope to terminal pulleys it has proved practicable to move this conveyor bodily sideways by the dragline shown in the illustration.

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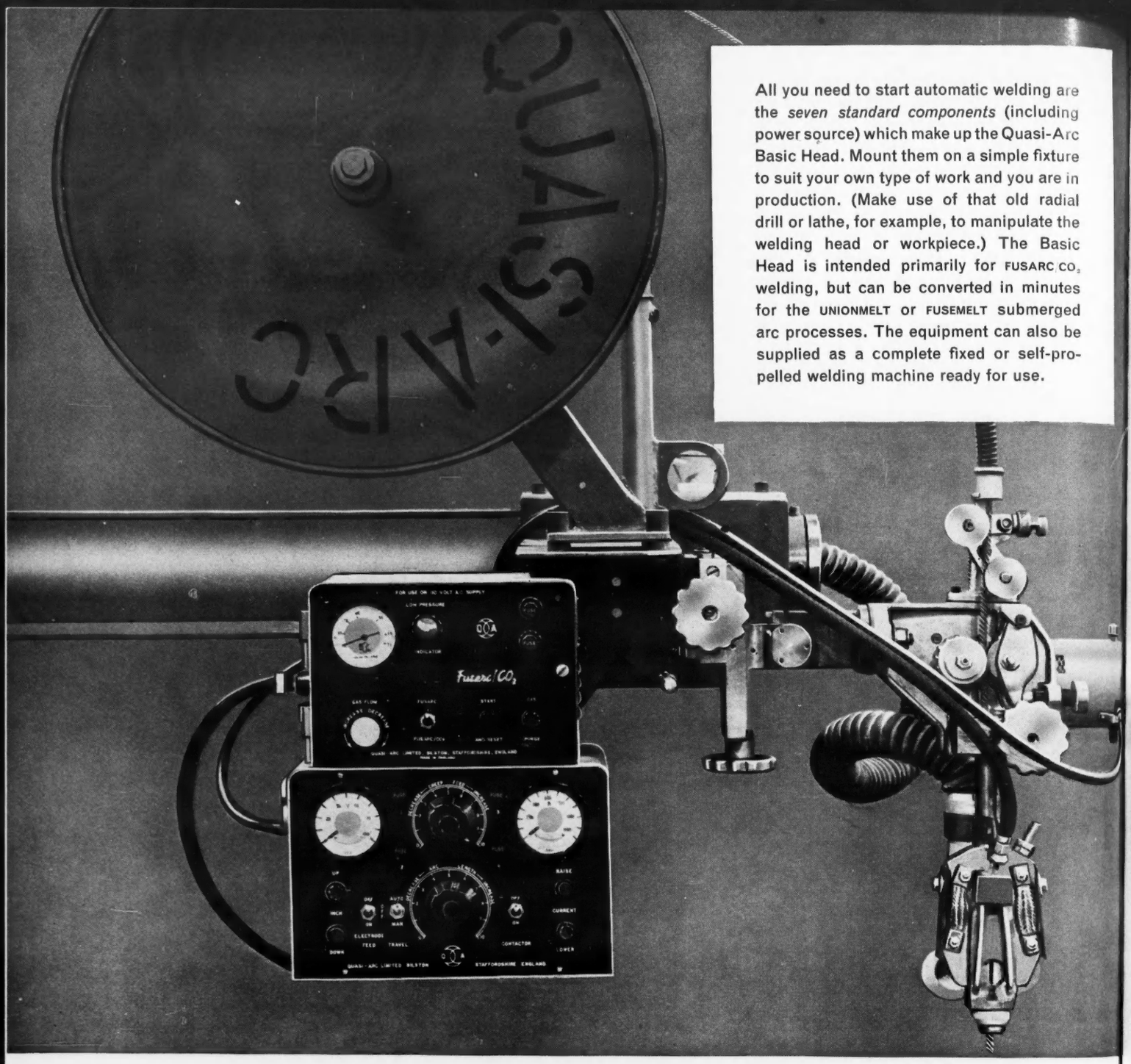

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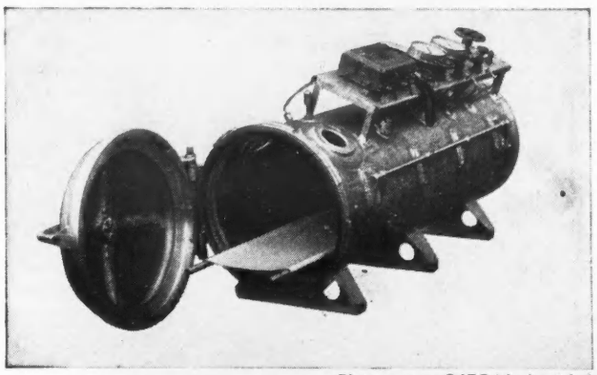

Photo: courtesy SARO (Anglesey) Ltd.

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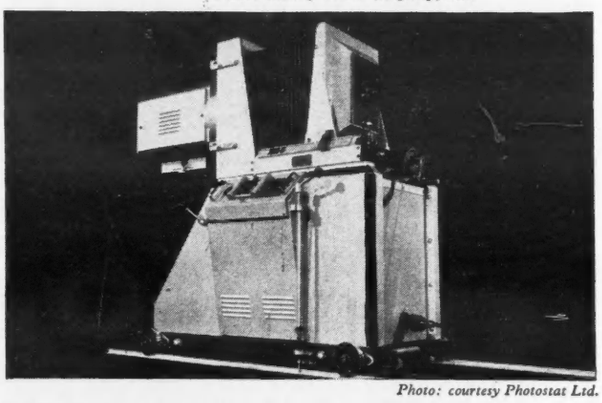

Photo: courtesy Photostat Ltd.

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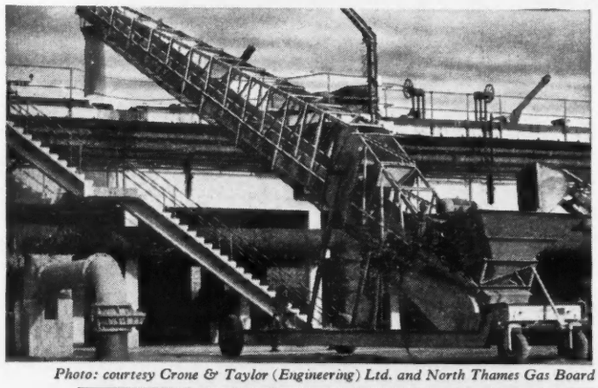

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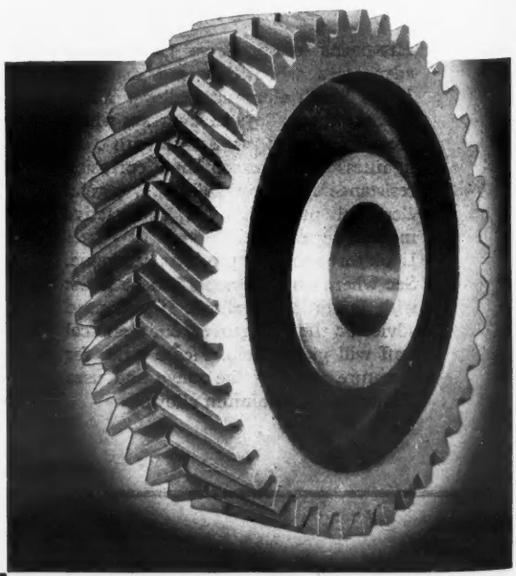

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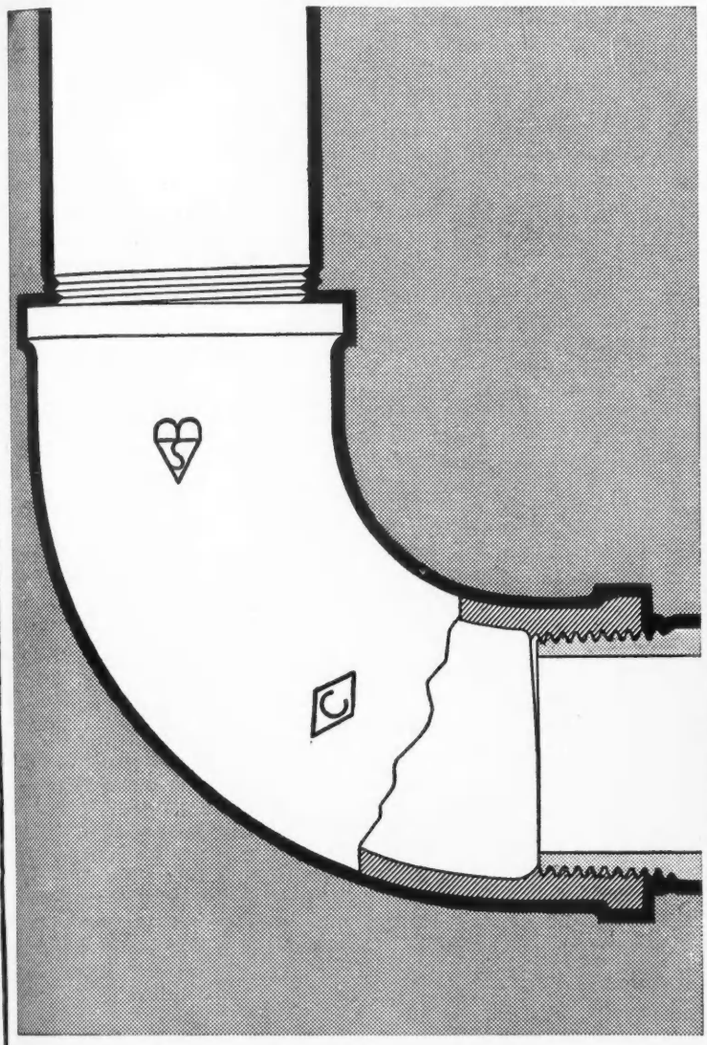

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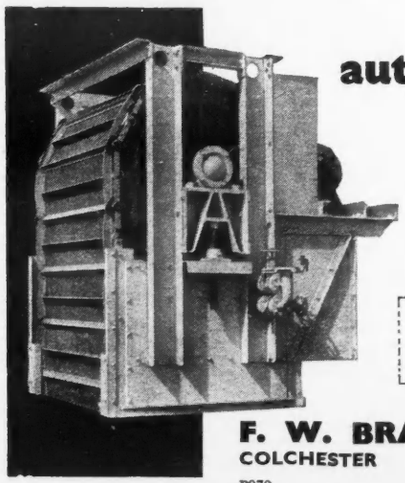

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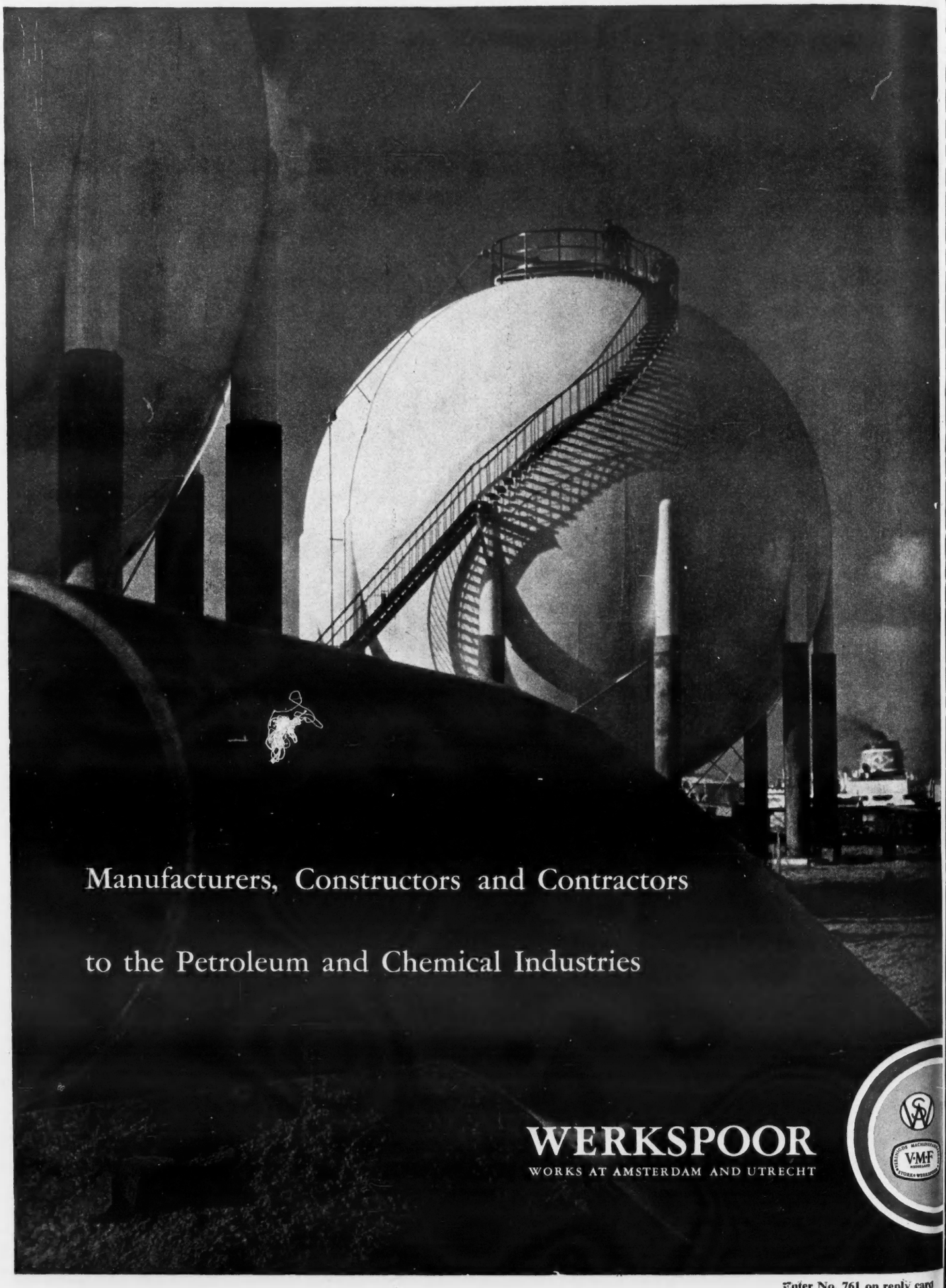
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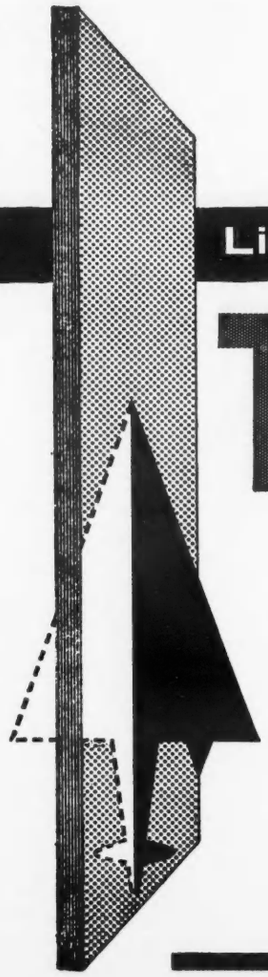

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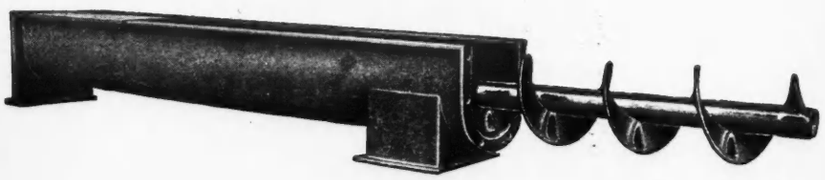

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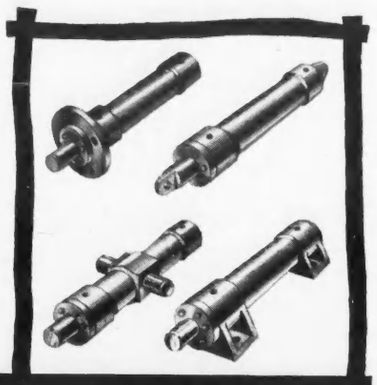

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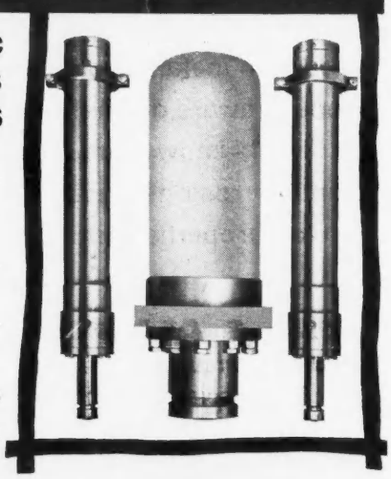

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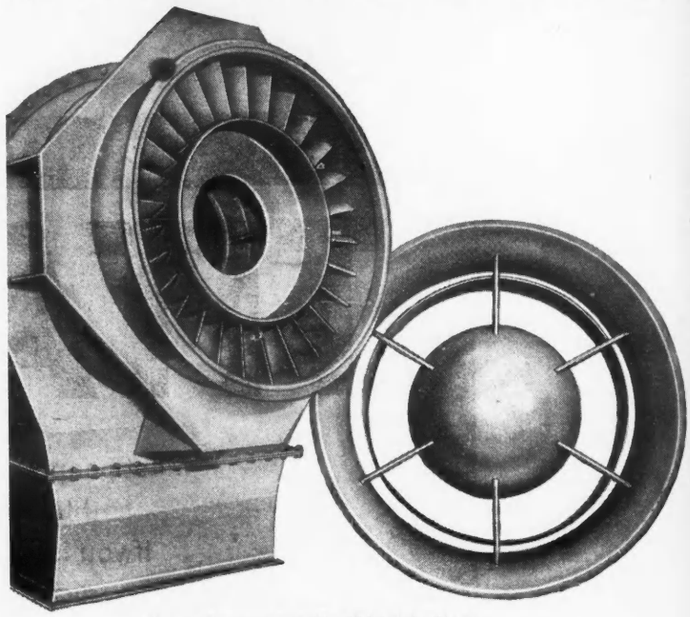
STEEL FABRICATIONS



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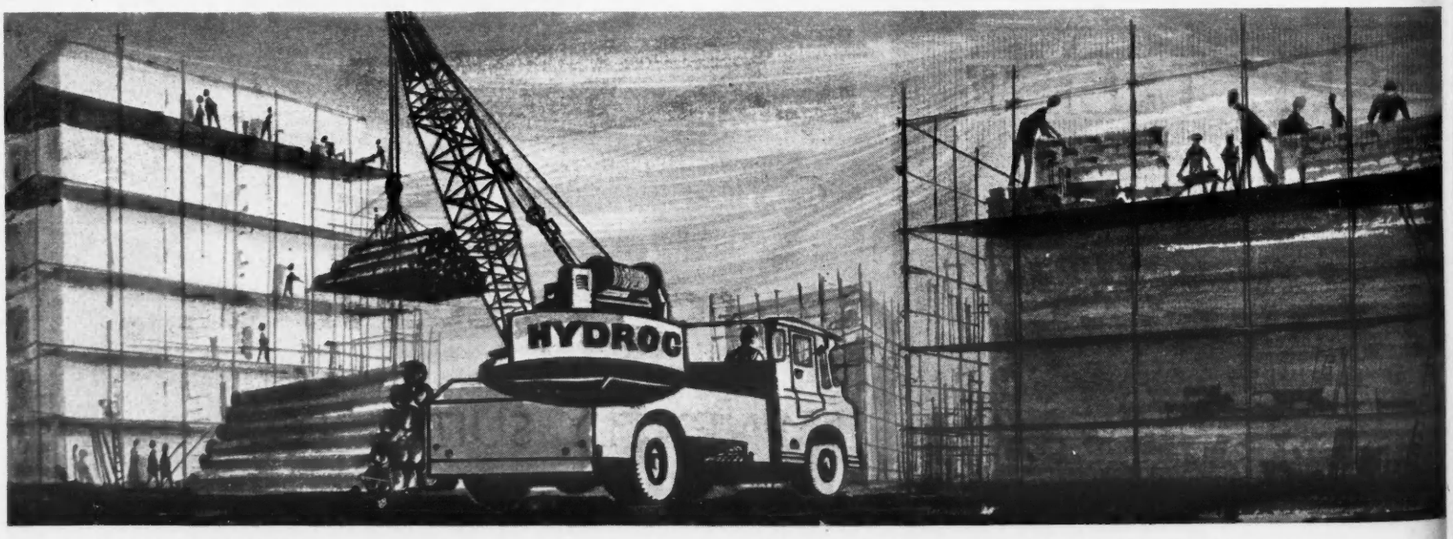

The 'HYDROCON HIGHLANDER' is winning friends all over the world. Managements are enthusiastic over its many advanced technical features which bring lower costs — higher profits. Operators acclaim the Hydrocon Highlander because it is utterly simple to use. Whenever materials have to be moved—this is the machine to move them—speedily, safely, *cheaply*.

One cab, one operator, full circle slewing. No clutches, no electric motors. Finger-tip controls, permitting 3 motions at once. Jibs up to 56', erected without mechanical assistance. Rapidly lowered outriggers with universal foot pads. Rotary Hydraulic Motors for precision control—full interchangeability—no maintenance. Fast winch speeds—'double safety' brakes—power lowering for precision control. One rope for all jib lengths. Winch parts 90% interchangeable. 5 ton capacity—fully slewing model

★ROBUSTLY CONSTRUCTED THROUGHOUT

The Hydrocon Highlander is fully described in colour brochure. Please write for your copy.

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Sole distributors in England and Wales: BROWN & TAWSE (PLANT) LTD., Ambrose Street, West Gorton, Manchester, 12. *Grams: Hexameter Manchester 12. Tel: Manchester East 2231 (5 lines).* Also at Birmingham and London.
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The most stringent-ever pre-marketing tests and operational service in all conditions have proved that Ruston air-cooled diesels consistently outperform and outlive comparable engines. Their sheer dependability and round-the-clock slogging power pay off as profit for the plant user. Profit for **you** when you specify Ruston air-cooled diesels.

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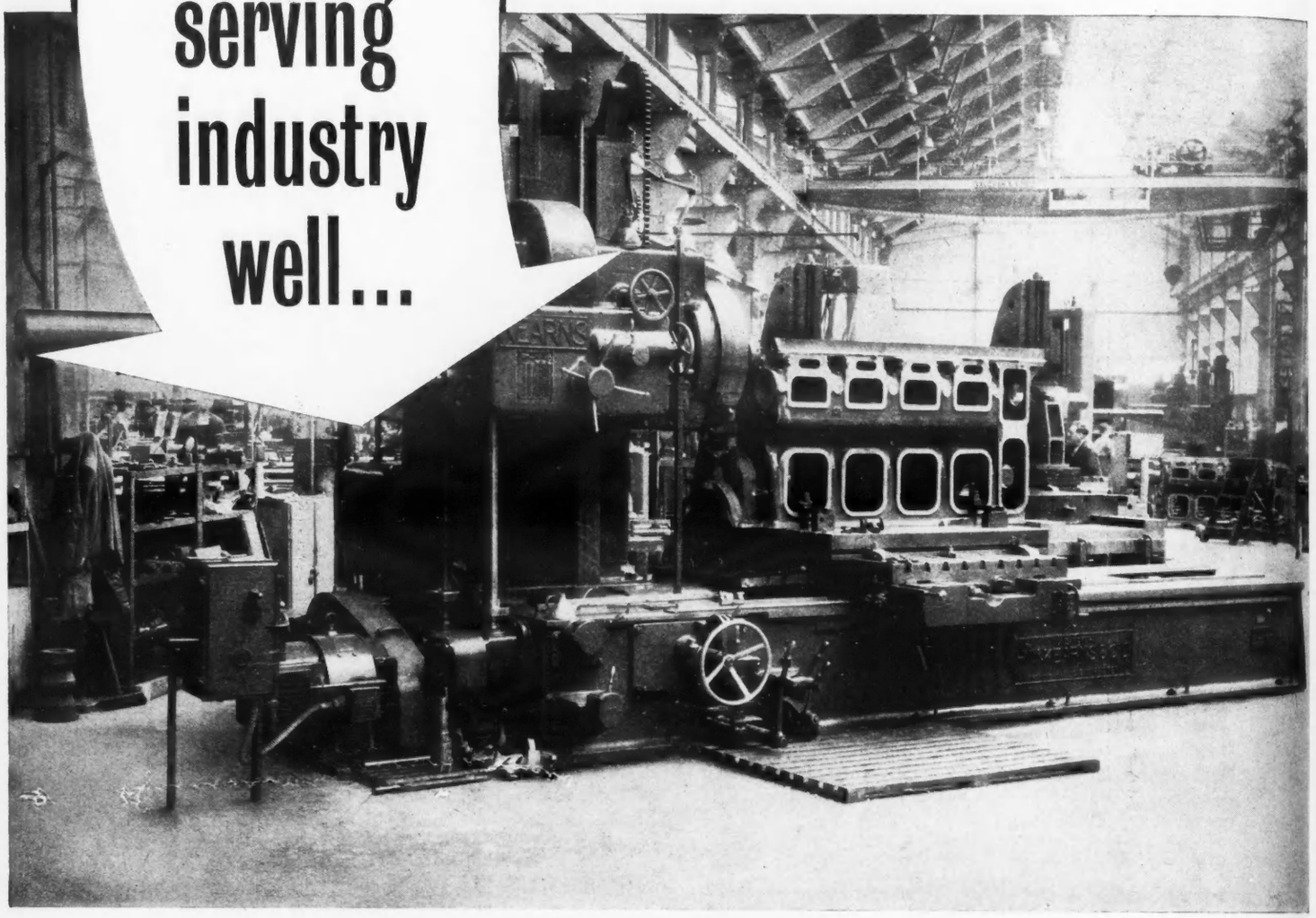

No. 5 Kearns Patent Machine machining an oil engine crankcase casting at the works of The Vulcan Foundry Limited.

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horizontal surfacing and boring machines for precision in every capacity

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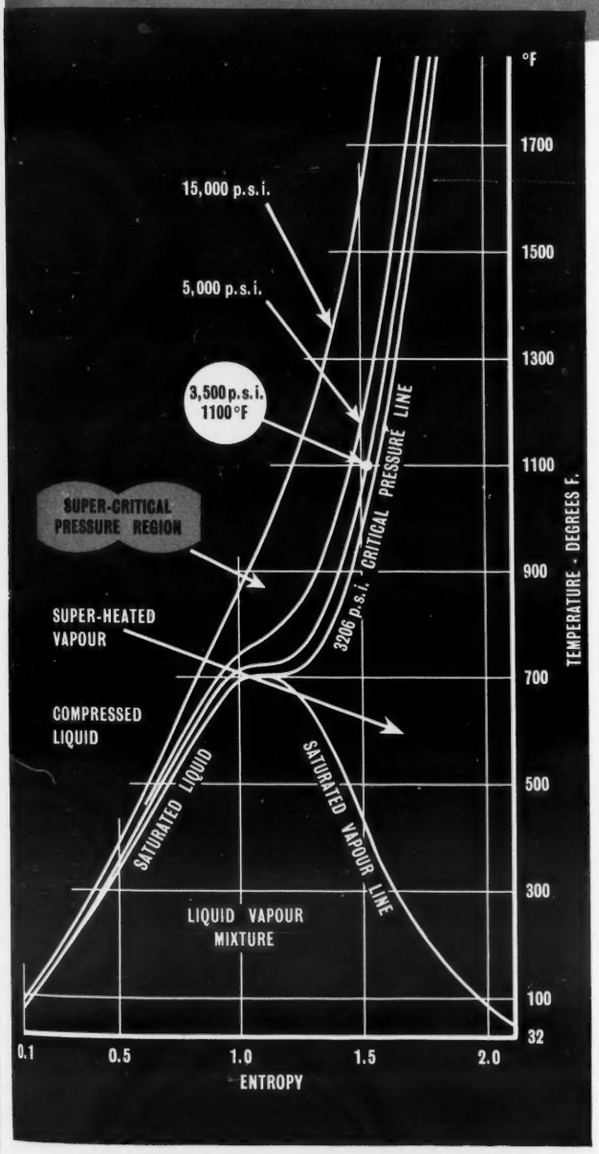

The ENGLISH ELECTRIC Company Limited has received instructions from the Central Electricity Generating Board to put in hand one of two 375 MW single-line turbo-generator sets for operation at 3,500 p.s.i.g., 1,100°F., re-heating to 1,050°F.

The sets are for the Board's new Drakelow C Power Station and the No. 11 machine for which instructions have been given to 'ENGLISH ELECTRIC' is planned to commission in 1965.

This event marks the Company's pre-eminent position in the development and manufacture of advanced steam turbo-generating plant as shown by the orders placed with 'ENGLISH ELECTRIC' for the earlier prototype machines:

1959 **First 350 MW 2,300 p.s.i.g.,1,050°F.,1,050°F.re-heat**
1958 **First 275 MW 2,300 p.s.i.g.,1,050°F.,1,050°F.re-heat**
1955 **First 200 MW 2,350 p.s.i.g.,1,050°F.,1,000°F.re-heat**

'ENGLISH ELECTRIC'

steam turbines

THE ENGLISH ELECTRIC COMPANY LIMITED, MARCONI HOUSE, STRAND, LONDON, W.C.2.

Steam Turbine Division, Rugby

WORKS: STAFFORD · PRESTON · RUGBY · BRADFORD · LIVERPOOL · ACCRINGTON

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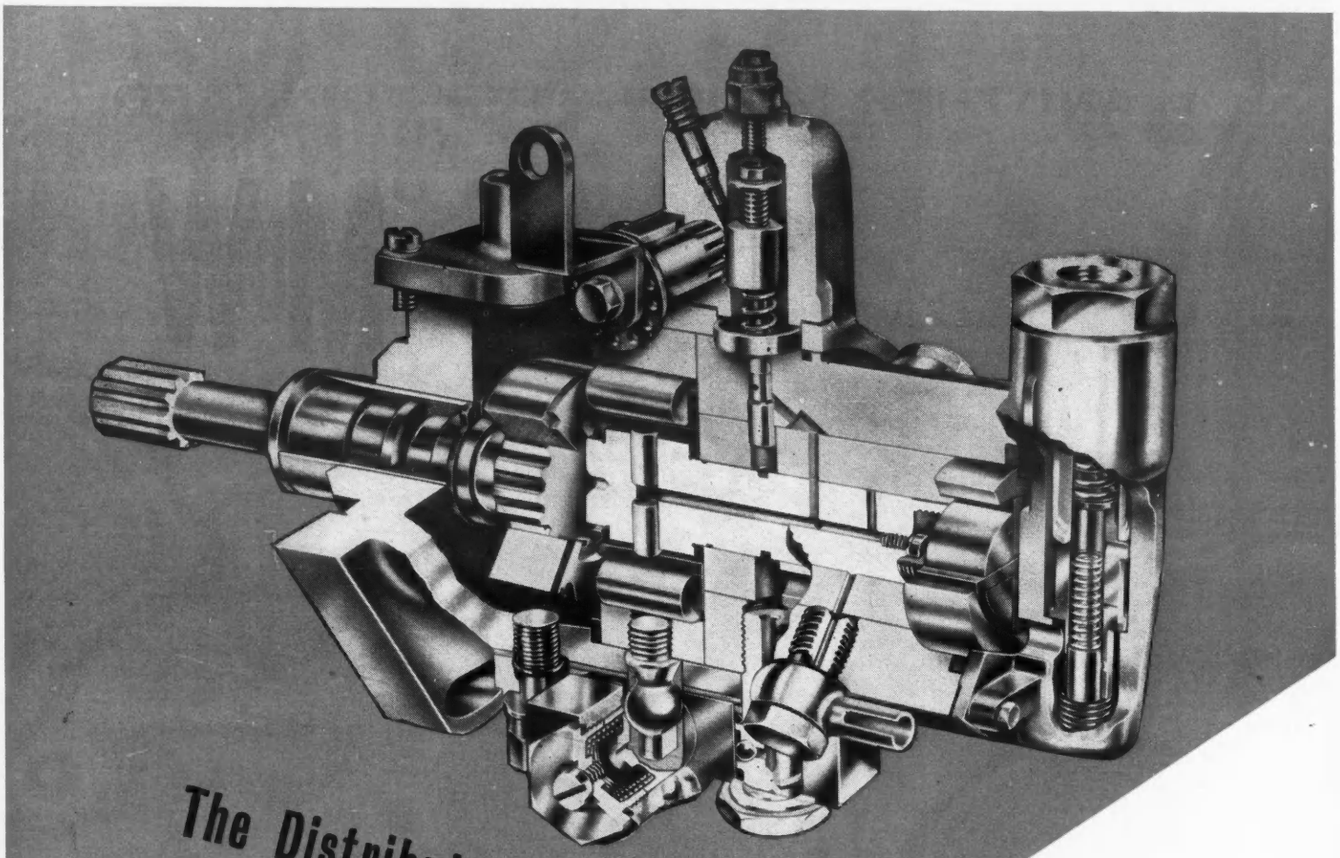
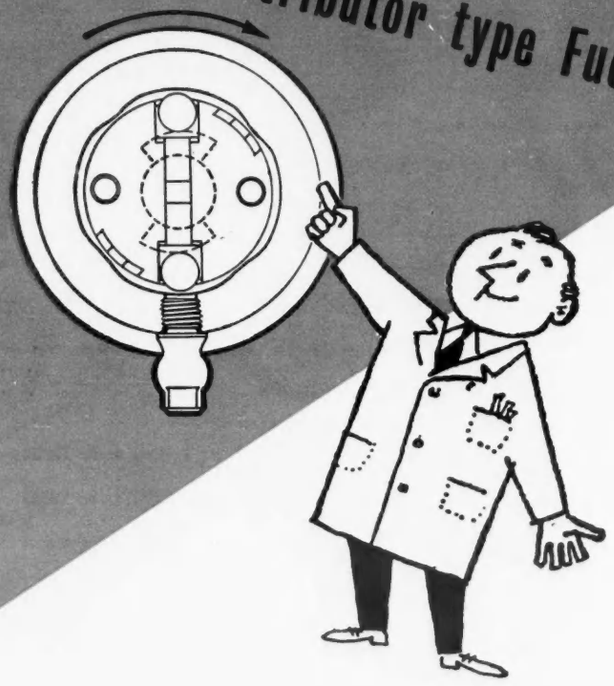


The Distributor type Fuel Injection Pump



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The DPA pump is basically simple in design, and has one pumping element only. This delivers fuel to each cylinder in turn, through the distributor. Accuracy of delivery is 'built-in' by high precision machining. No phasing or calibration is required. There are no highly stressed springs—the opposed plungers are returned by oil pressure. The complete unit operates in filtered fuel oil, and wear is negligible. The DPA is ideally suited for high speed diesels—already over a third of a million are in use throughout the world.

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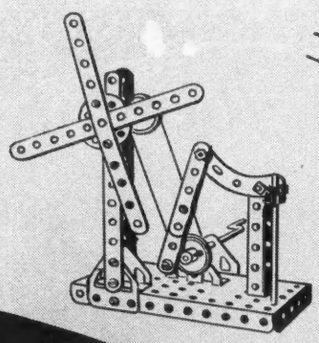

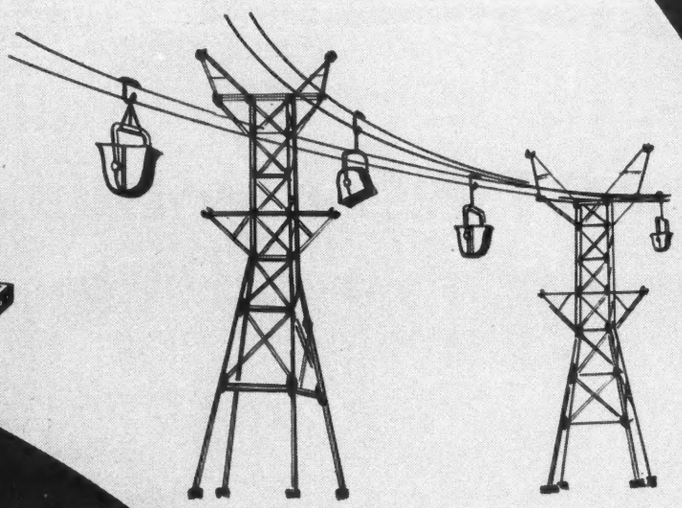

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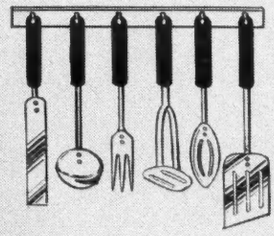

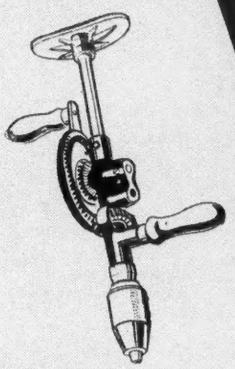

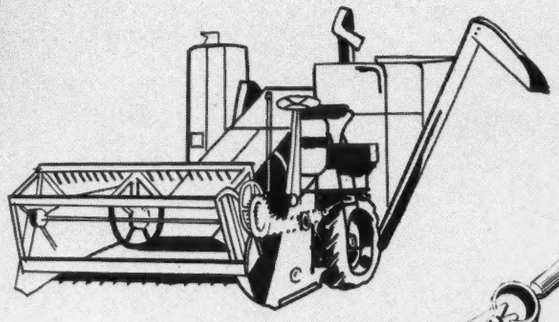

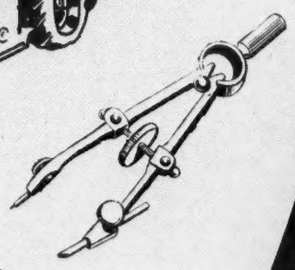

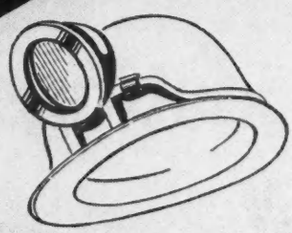

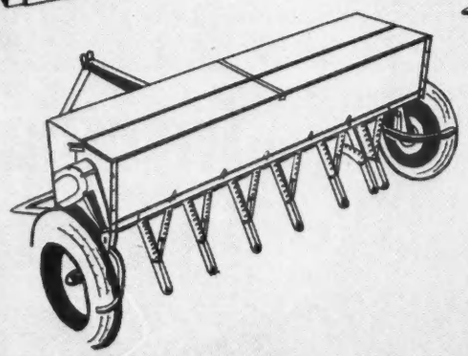

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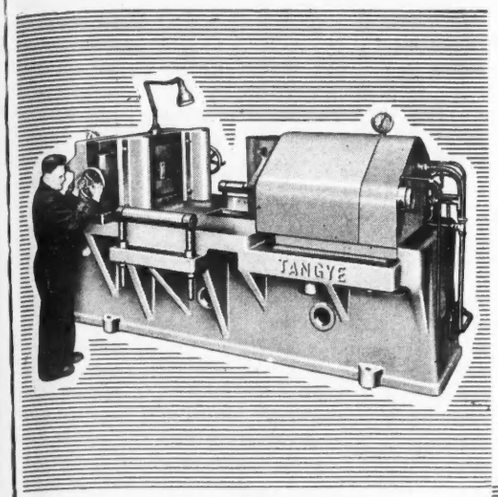


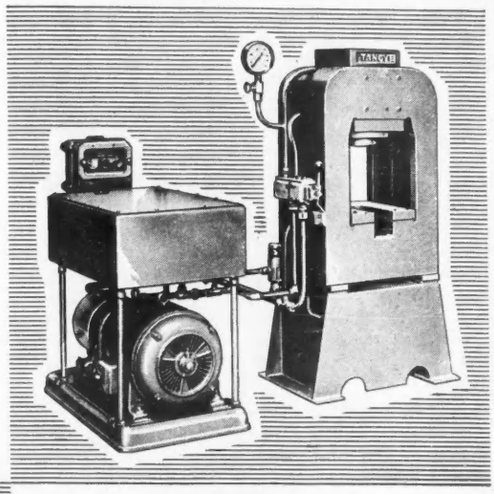
FOR BENDING OR STRAIGHTENING AND CERTAIN CLASSES OF FORGING

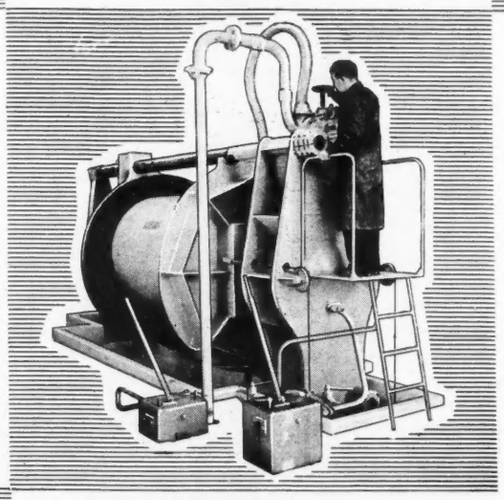
This range of Horizontal Open Gap bending presses covers capacities up to 200 tons. Two adjustable anvils are on the resistance head and a similar tool is on the moving platen attached to the ram head. Maximum daylight is 26in. After full-power operation, the ram is retracted by hydraulic rams situated at each side of the main ram. The anvils are easily removed and replaced by special tools when required. Equipment is provided to facilitate loading.

FOR PIPE TESTING

Large pipes requiring pressure testing, are clamped between two rubber-faced plates and are filled with water by either a gravity feed or by a Tangye centrifugal pump. Pressure build-up is then achieved by a Tangye hydraulic hand-pump.

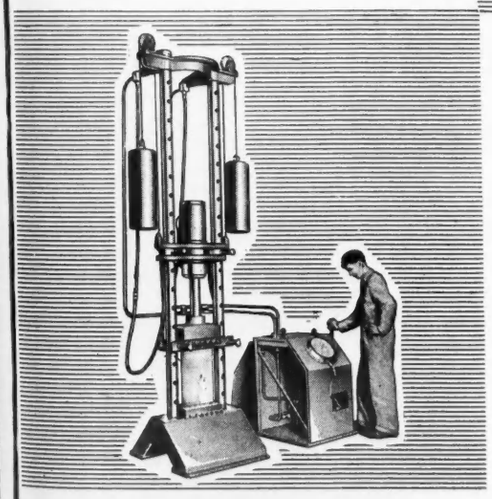
The view below is reproduced by kind permission of NORCON LTD., in whose test house Tangye equipment is well in evidence.





FOR COINING AND OTHER WORK

This neat and compact inverted press is 100 tons capacity. The table size is 15ins. by 16ins. with 15ins. daylight. The 8ins. diameter ram has a stroke of 5ins. A number of these presses are in use pressing watch cases.



FOR TESTING GLASS SHEET

This tensile-testing machine for glass sheets has a capacity of 30 tons. Daylight is variable between the two specially designed gripping units, from 1½ins. to over 6ft. The 6ins. diam. ram has a 12ins. stroke and is powered by a Tangye hand-operated pressure pump.

HYDRAULIC PRESSES & MACHINES

These examples are but a few of a large range of Tangye Hydraulic Machinery and Equipment.

Tangye Hydraulic Power in the experienced hands of the Hydraulic Division designers, is tailored to suit the exact operation it will be called upon to perform. It is therefore possible for us to gratify our Customer's every wish and we are not tempted to persuade him to " make do " with a standard design when we know we can offer something a little better.

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specifically designed for mining applications

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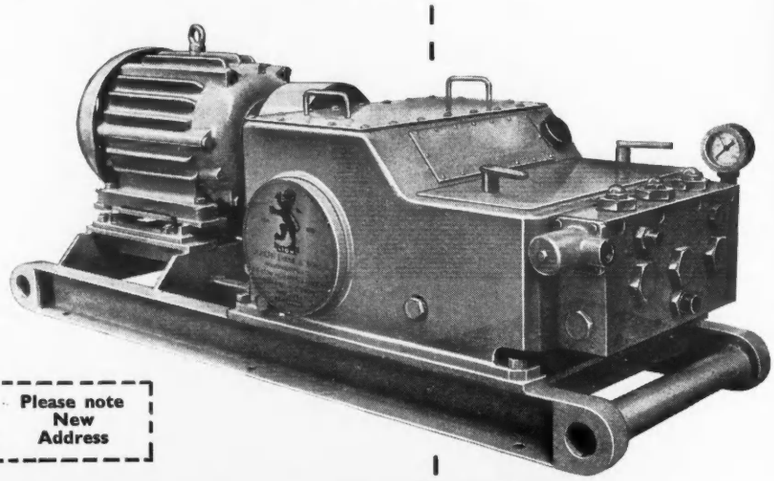

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The unit is suitable for operation with water, water/soluble oil mixture and hydraulic oil. Write for literature.

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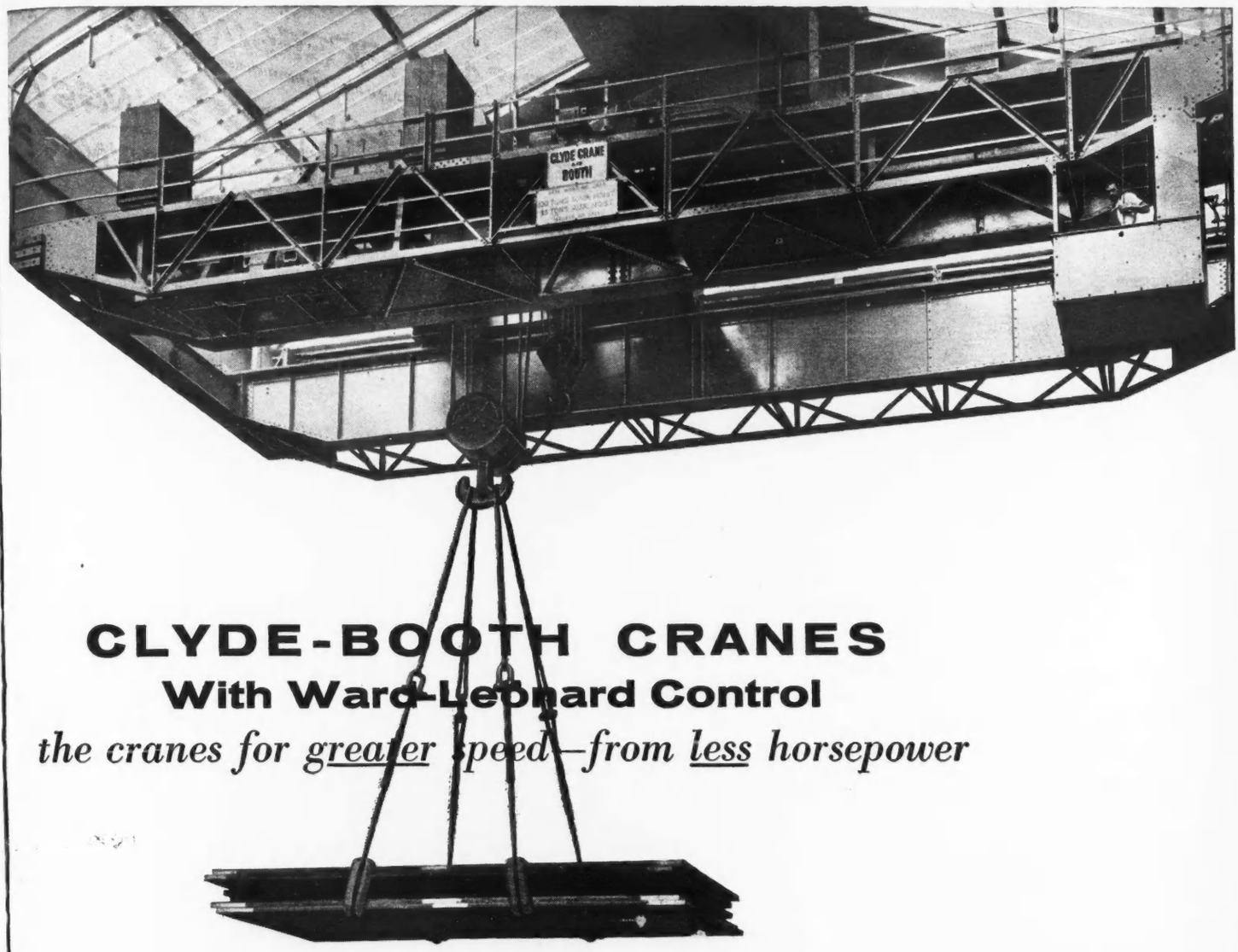

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the cranes for greater speed—from less horsepower

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CLYDE BOOTH NEWSLETTER No. 10 | fully describes the Ward-Leonard three-field control applied to an overhead travelling crane. Please ask for your copy.

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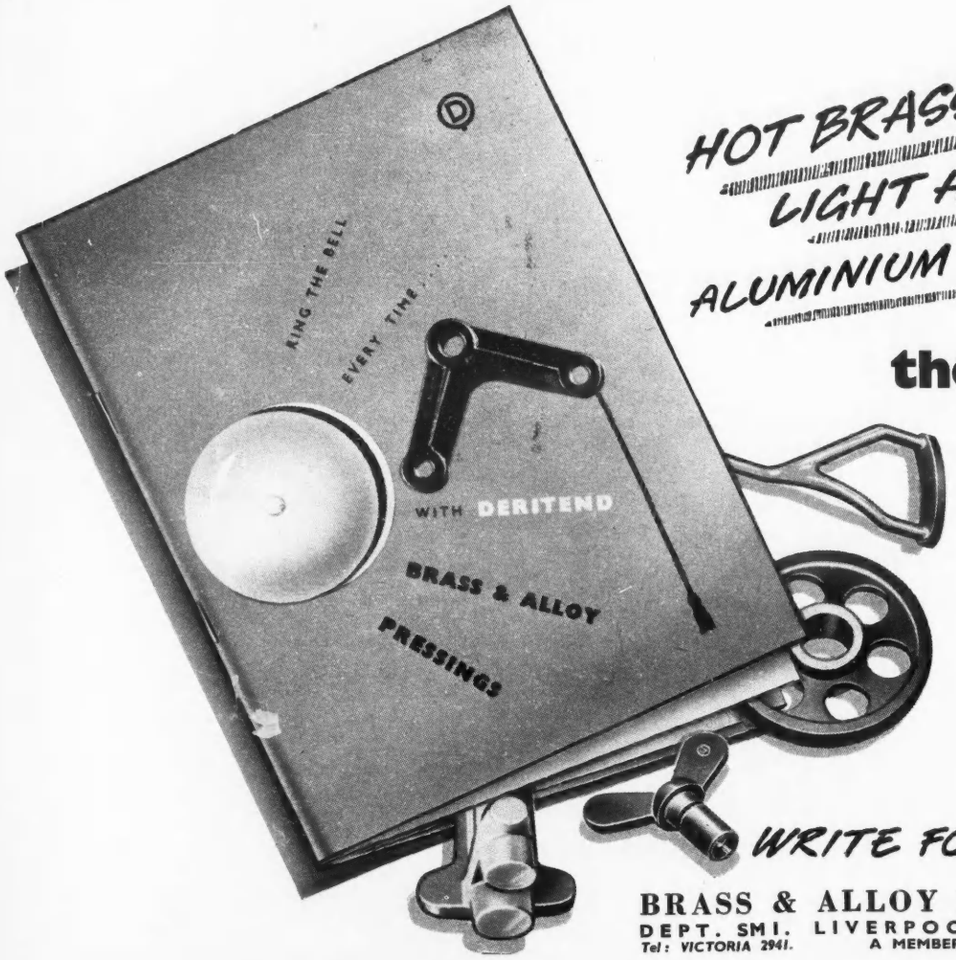

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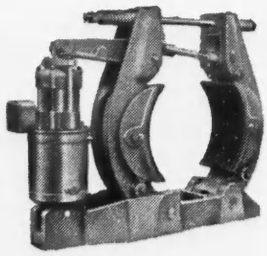

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(REGD. TRADE MARK)

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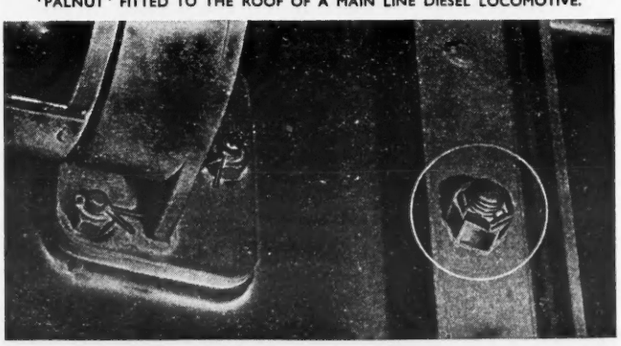
ECONOMICALLY AND EFFICIENTLY DEFY VIBRATION

BY COURTESY OF BRITISH RAILWAYS, SOUTHERN REGION, WE SHOW BELOW A 'PALNUT' FITTED TO THE ROOF OF A MAIN LINE DIESEL LOCOMOTIVE.



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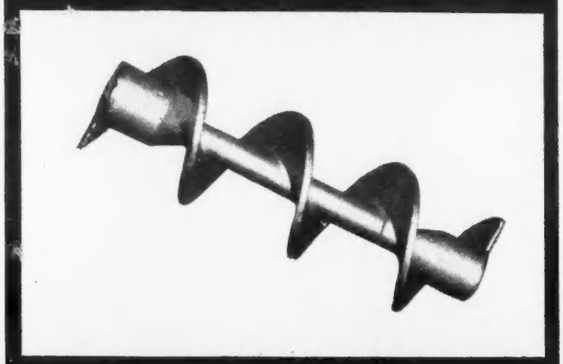

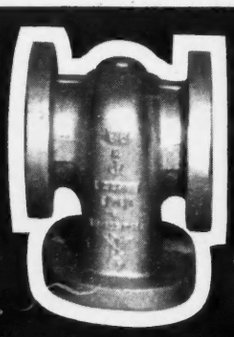

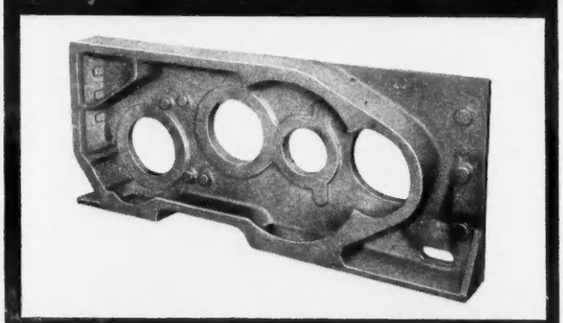

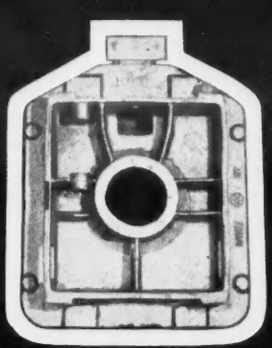

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All Alston steel castings are made by a unique process. Special mould and core mixes incorporating a new bonding medium result in satin-smooth castings requiring minimum machining. Thus, the high cost of tool replacement is minimised and a purer casting with better finish is produced in less time for the same price as ordinary castings.

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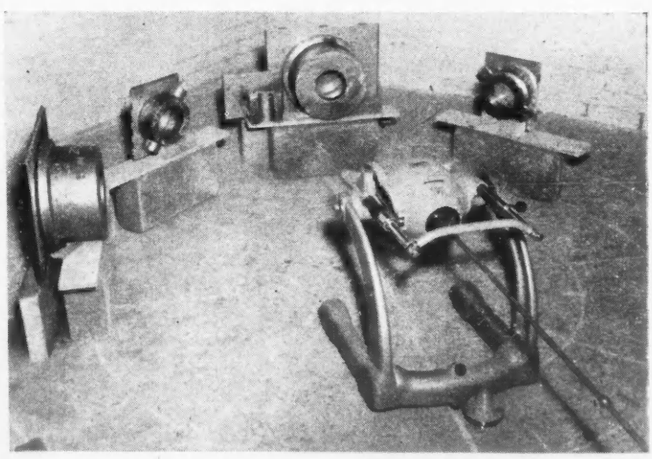

SCIENTIFIC CONTROL

Rigid quality control at every stage of production, culminating in stringent chemical and physical laboratory tests, Gamma-Ray and crack detection inspection, ensures absolute purity of casting.

ALSTON FOUNDRY CO. LIMITED

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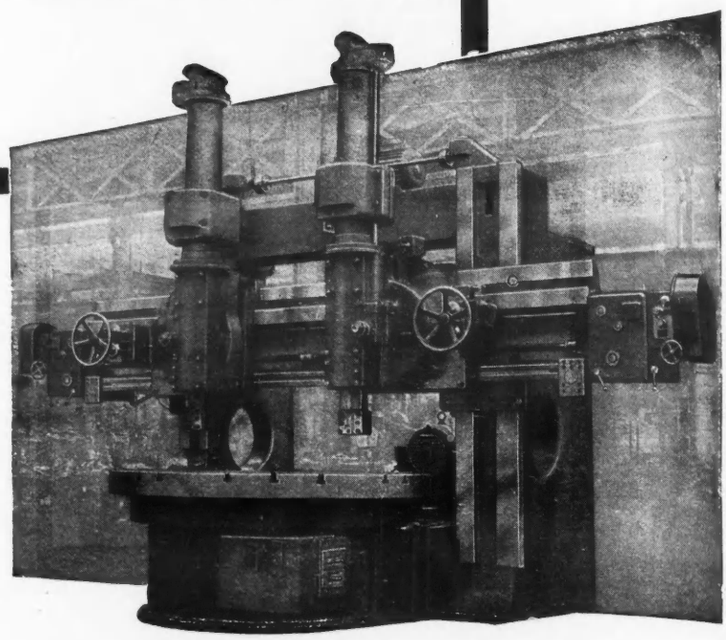

These machines are of heavy construction, each with a 30 h.p. constant-speed table driving motor and a twelve-speed gear box. Feed traverse to each saddle and its ram is by an independent variable-speed motor, and additional constant-speed motors are used for all quick traverse movements.

Duplicate control stations give complete pushbutton operation of the main motor and full selection of the ram and saddle movements, including change-over from feed to quick traverse and vice versa, the various engagements being made by magnetic clutch operation.

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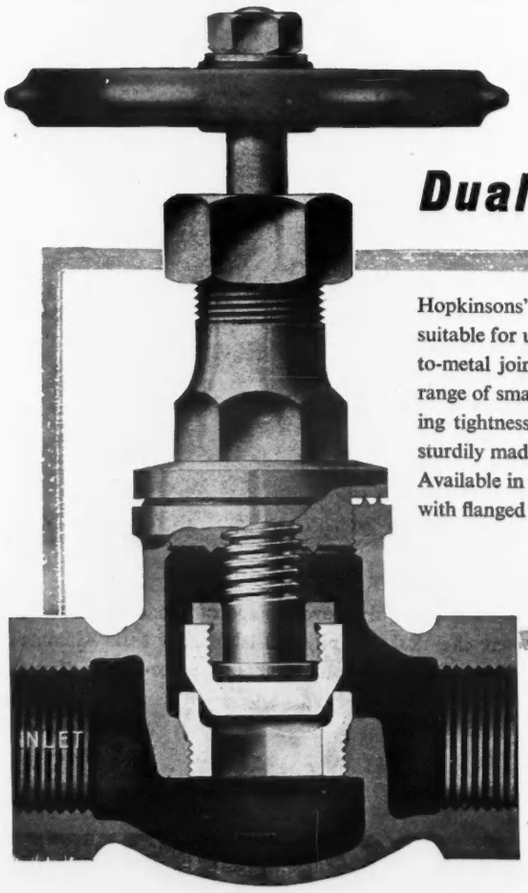

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Dual-Purpose Bronze Valves

Hopkinsons' "S.T.S." bronze valves, with their mitre-faced valve heads and seats are suitable for use as either isolating or regulating valves. Note how the tapering metal-to-metal joint between body and seat helps to ensure complete fluid-tightness. This range of small valves, in fact, is acknowledged by users to be exceptional for maintaining tightness over very long periods of service, so simply are they designed and so sturdily made.

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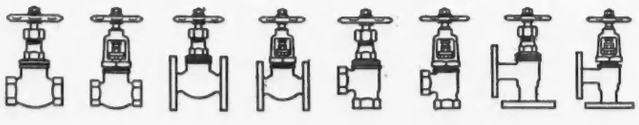

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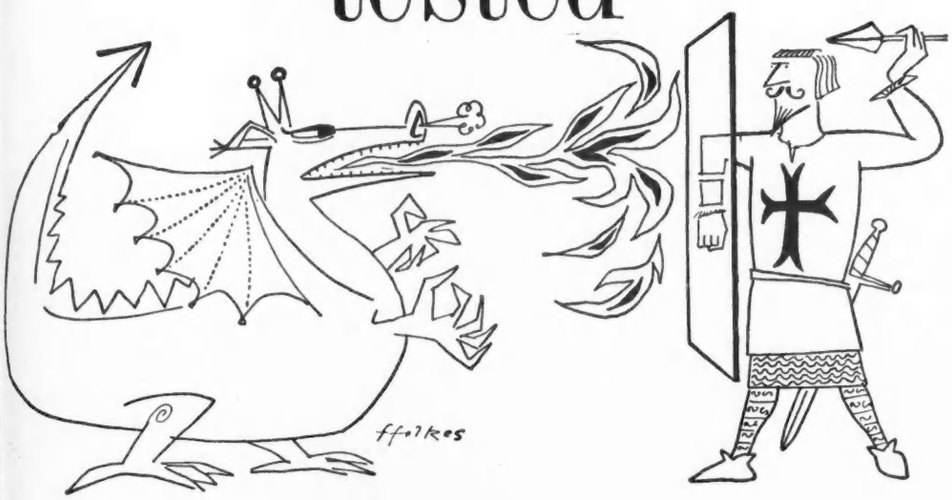
Heat-tested



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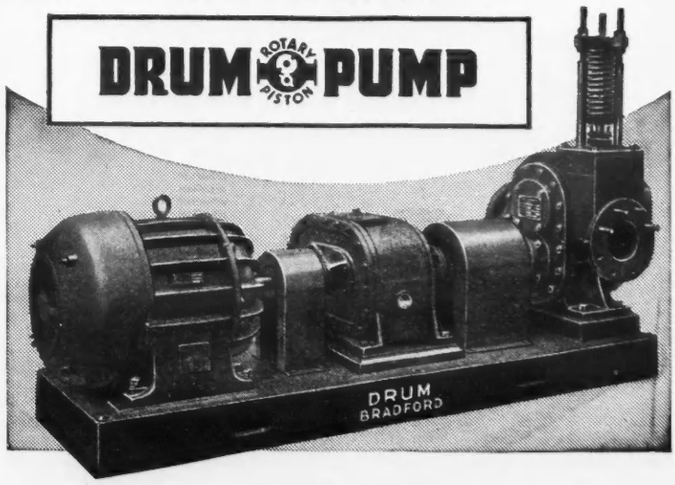

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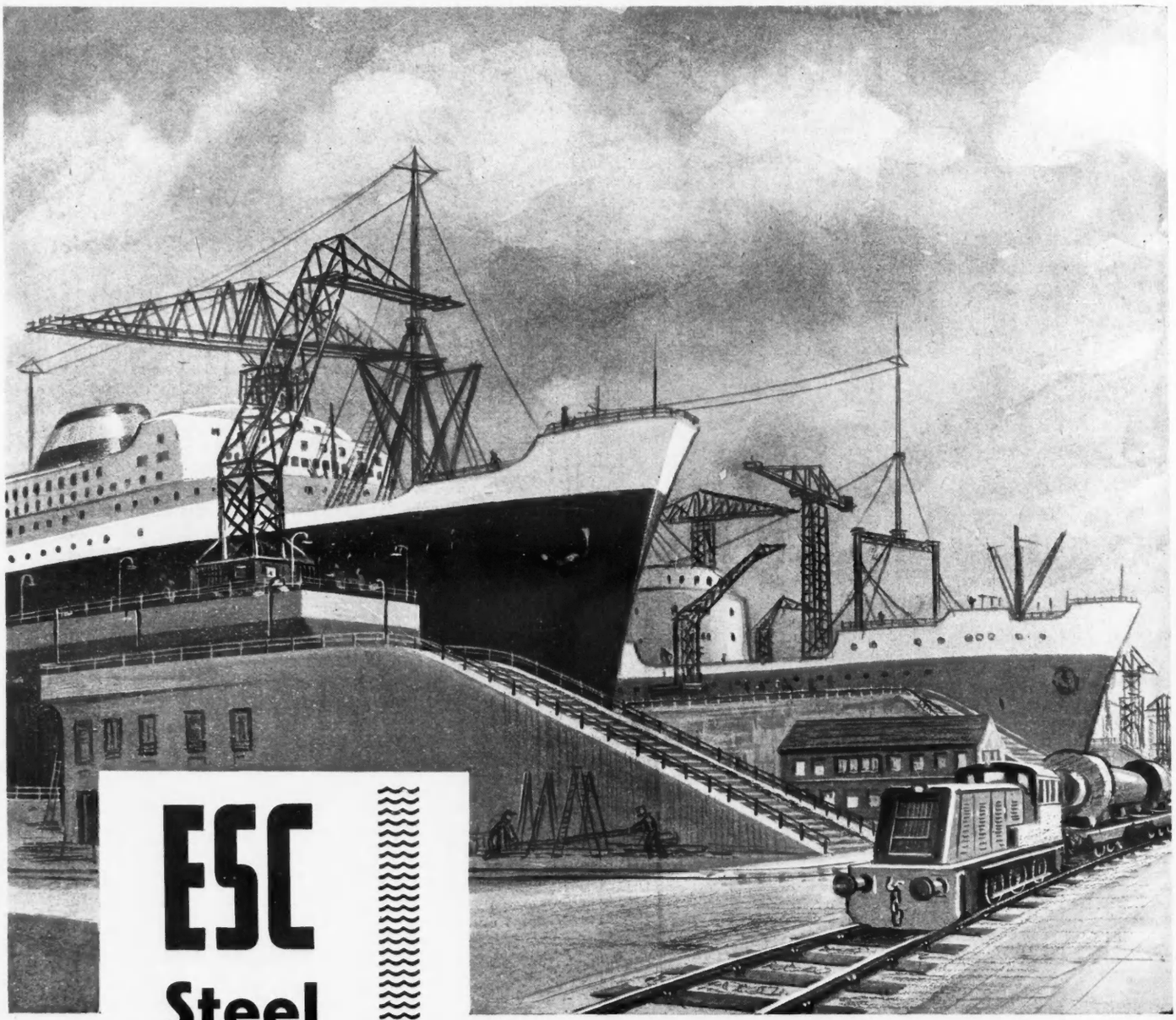

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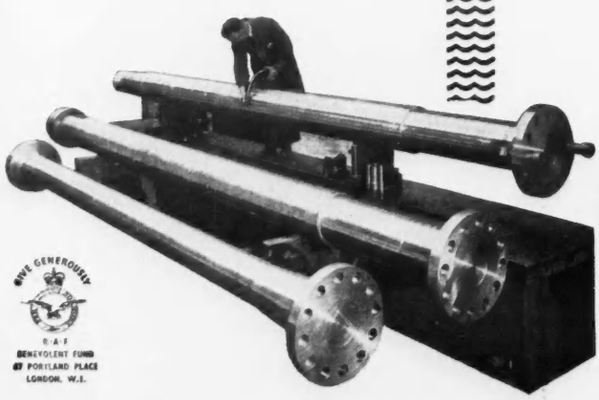

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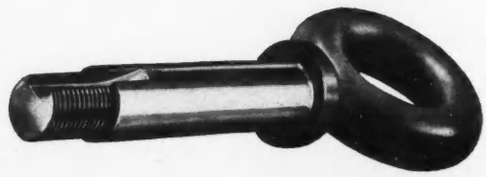

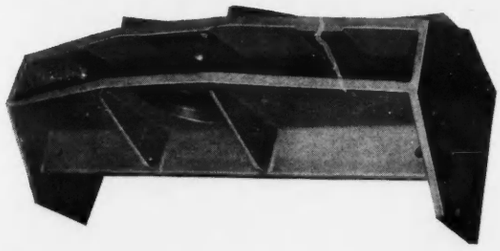

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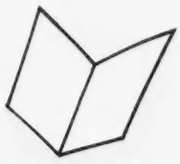

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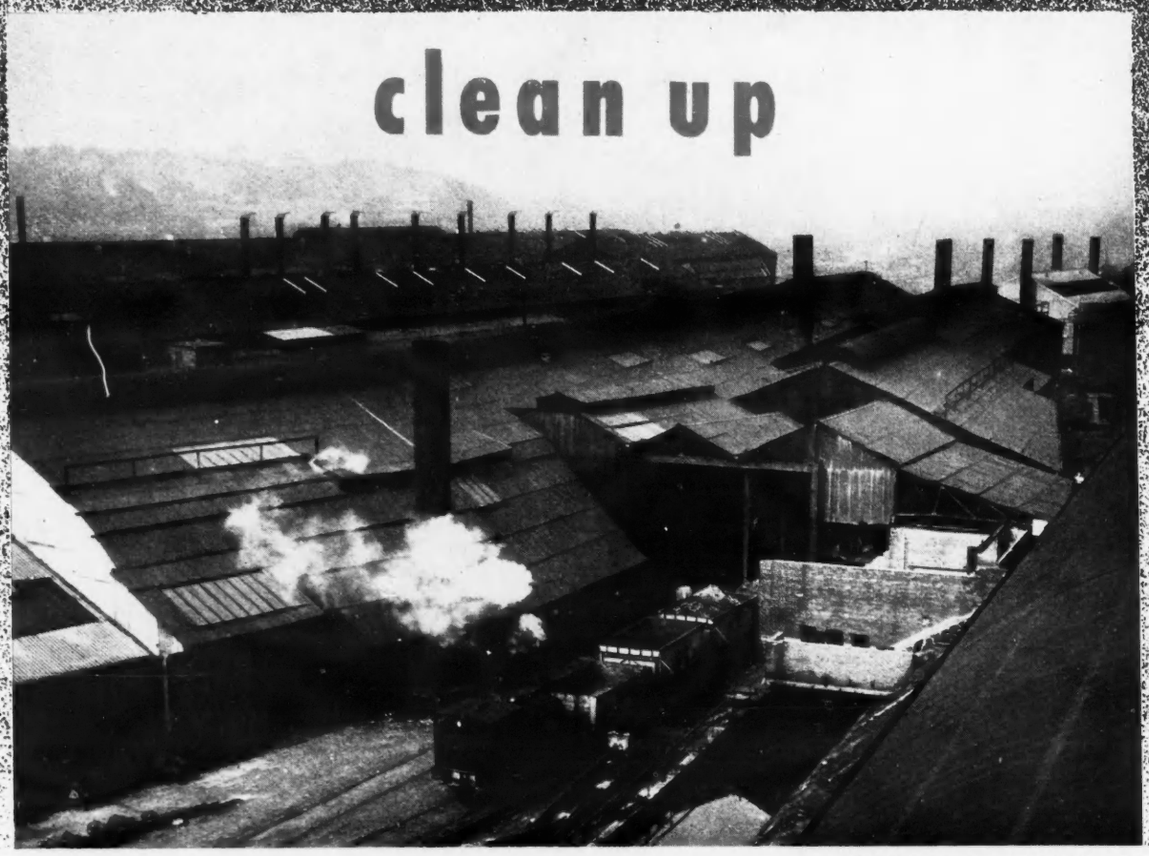

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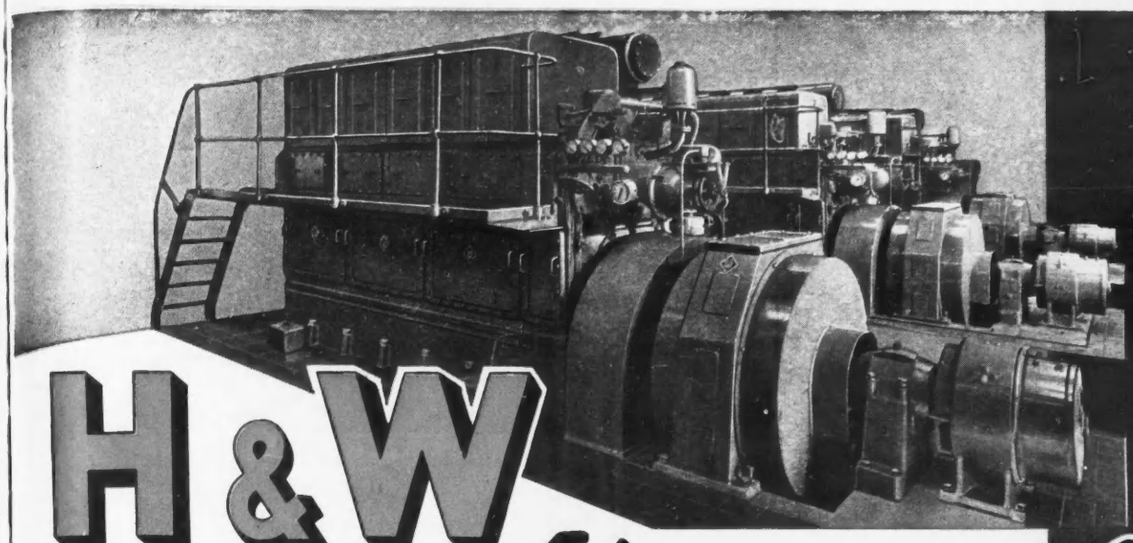

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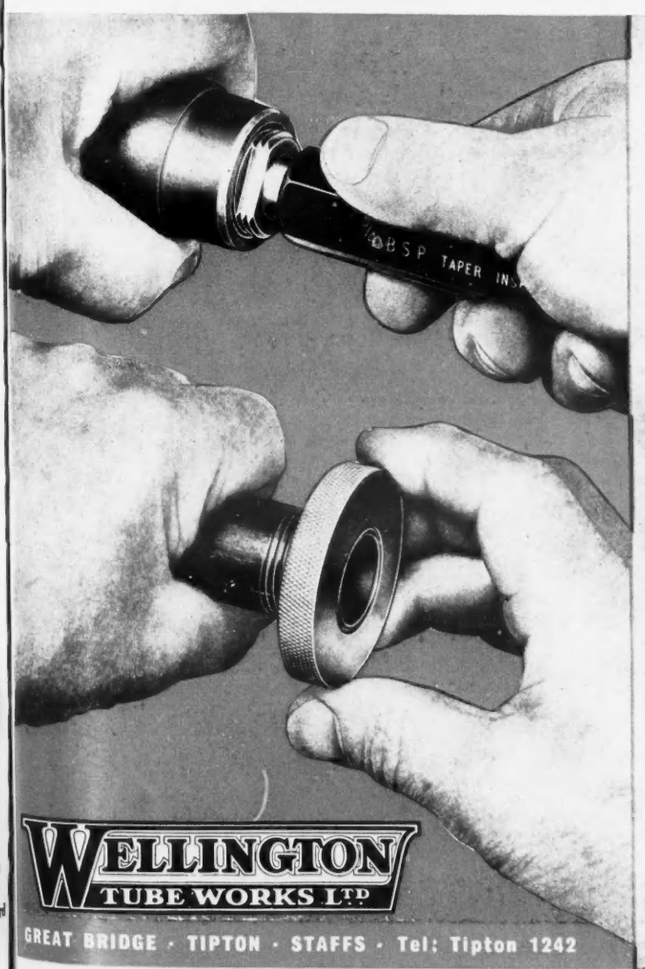

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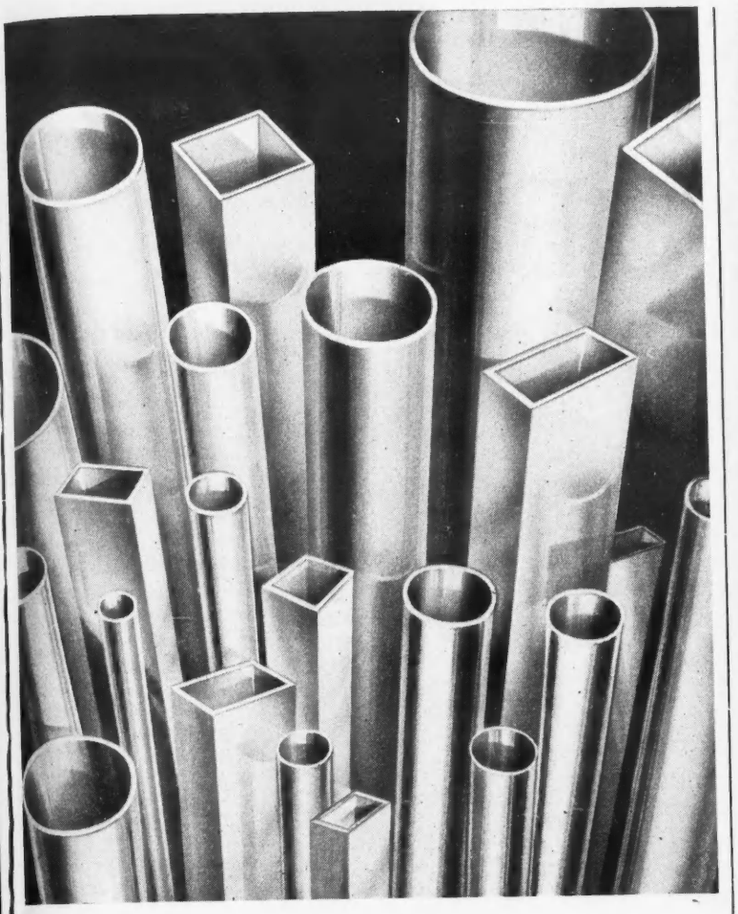

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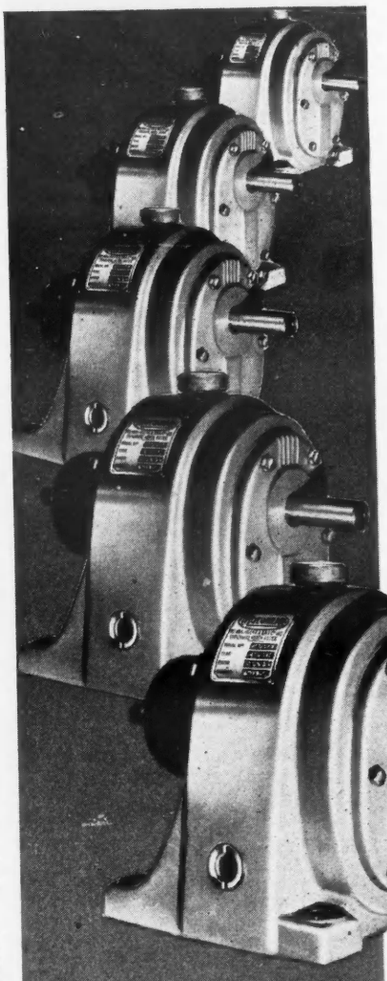

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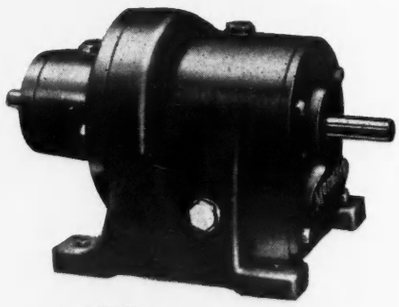

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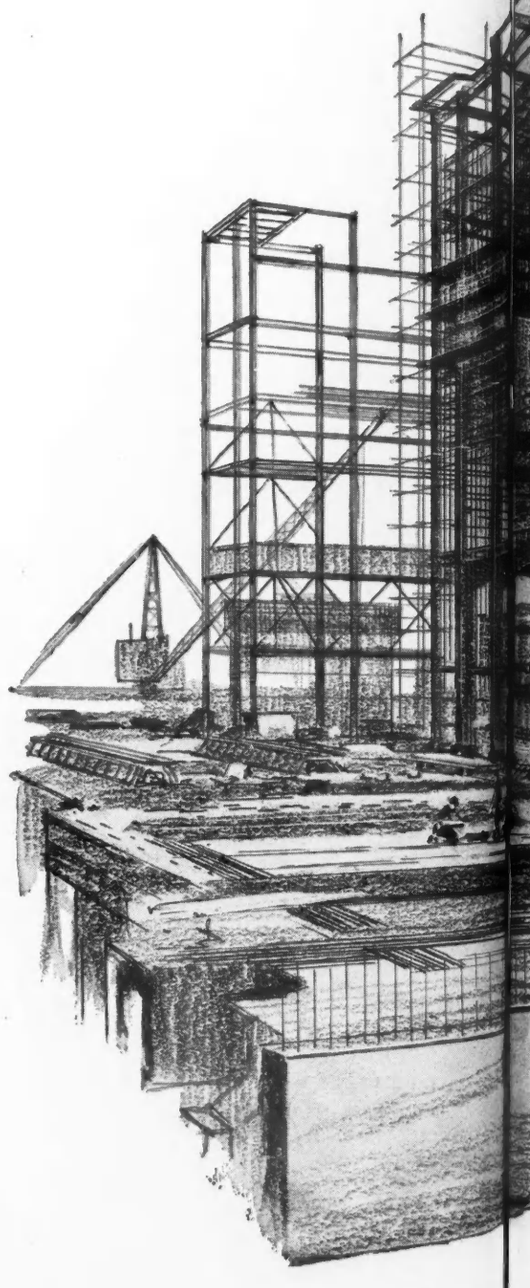

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ARCHITECTS: Farmer & Dark, F/F.R.I.B.A. Romney House, Tufton Street, London, S.W.1.

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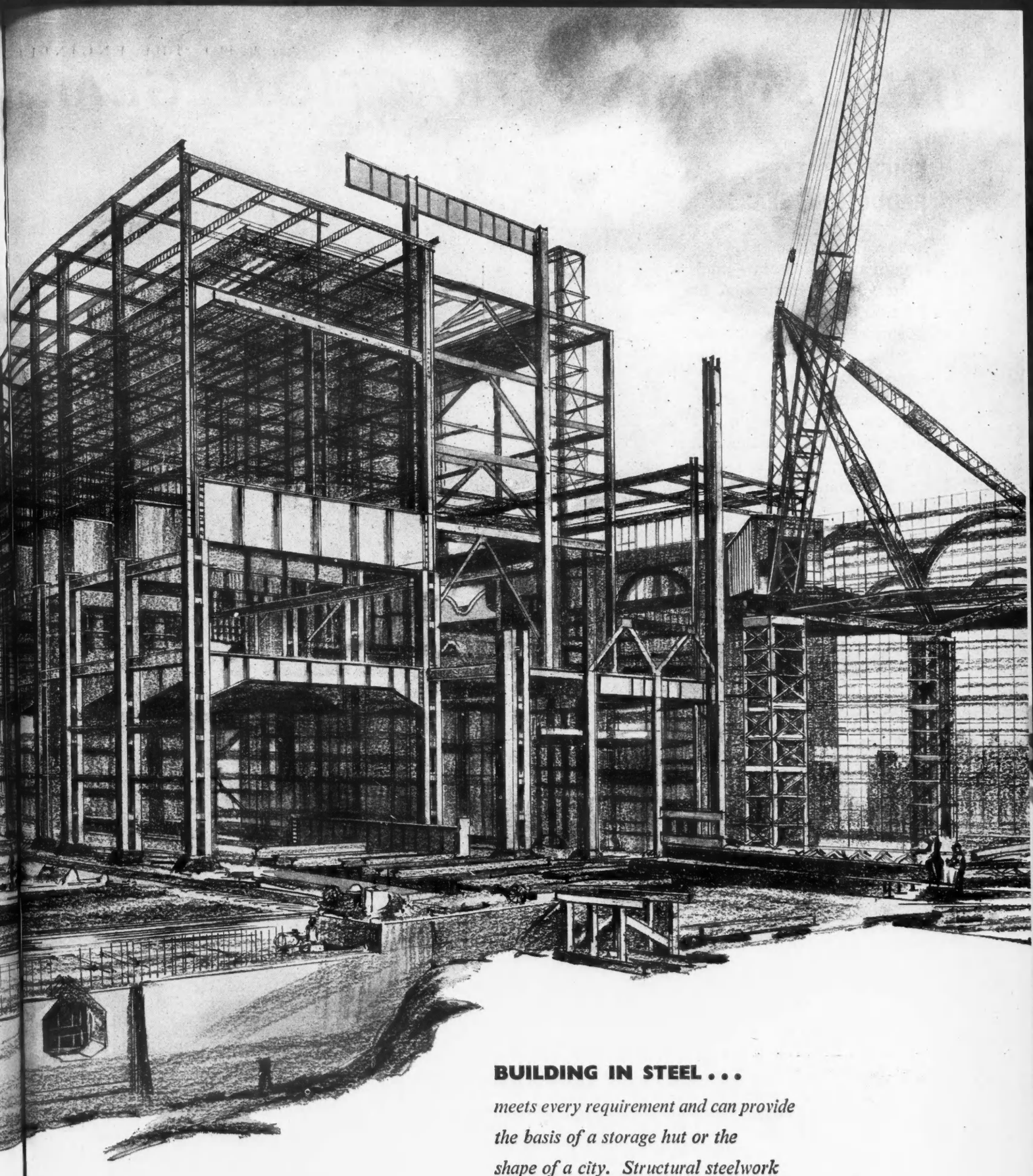

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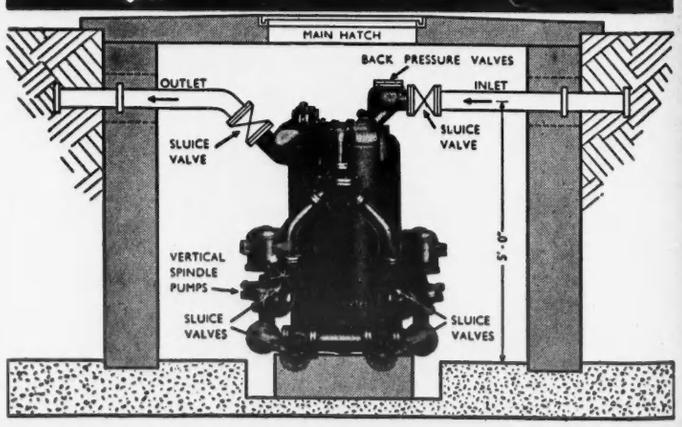

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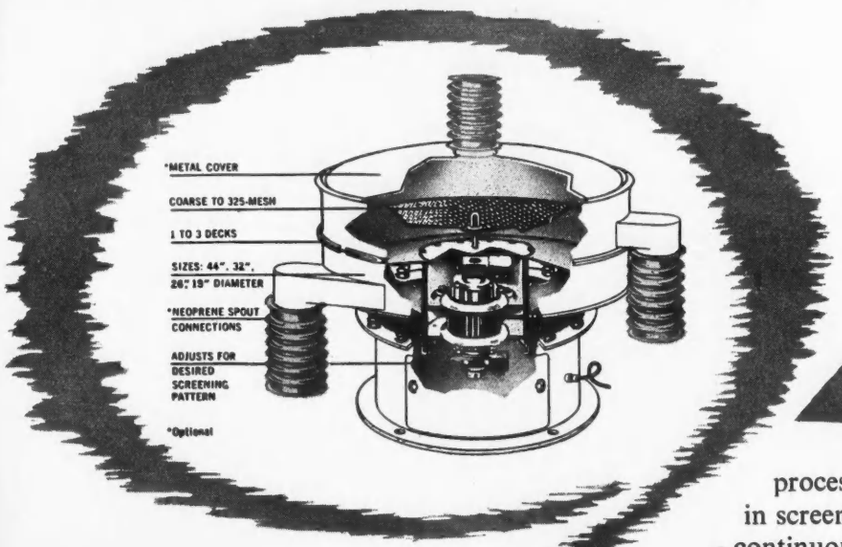

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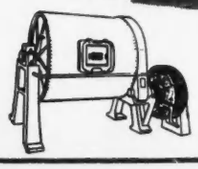
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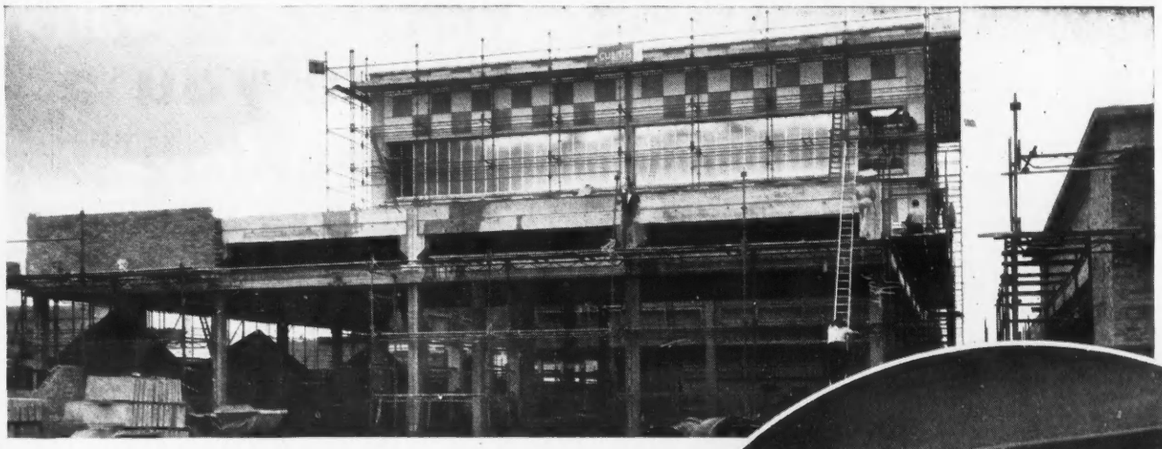

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Lineage Rate. 4/6 per line of approximately 6 words. Minimum 18/-. **Inch Rate.** 54/- per single column inch and pro rata. 12 lines to 1 inch.

There are reduced rates (i.e., not on a pro rata basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £29 10s. ½-page £54. Full page £100.

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Run-On and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/- which includes forwarding of replies.

Copy Dates. Tuesday for publication on Friday of the same week. If proofs are wanted, copy is required on Thursday for publication on Friday of the following week.

Advertisements for publication should be addressed to:—**Classified Advertisement Dept., "THE ENGINEER," 28 Essex Street, Strand, London, W.C.2**

Urgent advertisements may be telephoned to CENtral 6565.

PUBLIC APPOINTMENTS

UNITED KINGDOM TECHNICAL ASSISTANCE

SENIOR LECTURERS

Applications are invited for four appointments as SENIOR LECTURER at the Technical College, Kuala Lumpur, Federation of Malaya, in :

1. ELECTRICAL ENGINEERING
2. MECHANICAL ENGINEERING
3. CIVIL ENGINEERING
4. CHARTERED SURVEYING.

Candidates should possess a good University degree (or equivalent) and have had teaching experience in a Technical College at H.N.C. level. Corporate Membership of Professional Institutions an advantage. Experience in Topographical Surveying (including Aerial Surveying) desirable for the Lectureship in Chartered Surveying. Salary, £1750 p.a. (subject to U.K. income tax) plus tax-free overseas allowance of £1465 p.a. (married) or £865 p.a. (single) plus other allowances and free furnished accommodation. Contract with, and all emoluments paid by, U.K. Government. Duration three years. Age limit 50. For further information and application forms write Ministry of Labour (E.9), 26-28, King Street, London, S.W.1, quoting 1, 2, 3 or 4 and E.9/TCS/6. E5771

UNIVERSITY OF LEEDS

THE HOULDSWORTH SCHOOL OF APPLIED SCIENCE

RESEARCH ASSISTANT

Applications are invited, from suitably qualified candidates in the appropriate branches of physics, engineering or chemistry for the position of RESEARCH ASSISTANT to carry out fundamental work on the anomalous fracture-behaviour of high-temperature materials. Candidates will be encouraged to present the results of their work for a higher degree. The programme of work is intended to last for three years and will carry a salary within the range £800 to £1200 a year. Applications should be sent to Professor A. L. Roberts, at the Houldsworth School of Applied Science (from whom further particulars may be obtained) as soon as possible and not later than Saturday, 1st October, 1960. E5718

H.M. DOCKYARD TECHNICAL COLLEGES

ASSISTANT LECTURERS

ASSISTANT LECTURERS (Grade "A" or "B"). Pensionable (non-contributory) posts for men : two in Electrical Engineering (Portsmouth and Rosyth) ; one in Mechanical Engineering (Rosyth) ; one in Mathematics and/or Physics (Rosyth). Ability to help with other subjects essential. Appointment as soon as possible, preferably by January, 1961. Qualifications : University degree or equivalent and ability to teach special subject to H.N.C. standard. Burnham scales for Technical Colleges (no deduction for pension). Write Civil Service Commission, Burlington Gardens, London, W.1, for application form quoting S180/60. Closing date 23rd September, 1960. E5748

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

RESEARCH ASSISTANT

RESEARCH ASSISTANT required for wind tunnel investigation in the field of Industrial Aerodynamics. Successful applicant would be allowed to study for high degree or College Diploma. Salary in range of £600 to £900 with F.S.S.U. benefits. Apply to Head of Aeronautics Department, Imperial College, London, S.W.7. E5757

INSTITUTION OF GAS ENGINEERS

ASSISTANT SECRETARY

The Institution of Gas Engineers invites applications not later than 12th September, 1960, for the appointment of ASSISTANT SECRETARY at a commencing salary of £1750 per annum. Conditions from the Secretary, The Institution of Gas Engineers, 17, Grosvenor Crescent, London, S.W.1. E5642

PUBLIC APPOINTMENTS

BRADFORD INSTITUTE OF TECHNOLOGY

APPOINTMENTS

Applications are invited for the following posts :

READER IN MECHANICAL ENGINEERING

Candidates should possess the qualifications and experience to direct research and post-graduate work and to take a leading part in advanced teaching. Importance will be attached to industrial and research experience. Adequate facilities will be given to undertake research and suitable technical assistance and equipment are available.

Salary £1800 to £2100 per annum (or above in special cases).

PRINCIPAL LECTURER IN MECHANICAL ENGINEERING

Candidates should be qualified to teach to final degree and Diploma in Technology standard and should have adequate research and industrial experience. The successful candidate will be expected to assist the Head of the Department with the organisation and administrative work of the Department and will be encouraged to develop industrial contacts.

Salary £1750 to £1900 per annum.

Previous industrial or research experience at a suitable level will be taken into account in fixing the commencing salary.

Senior members of staff are encouraged to undertake consultant work in industry and may retain fees paid for such work.

Further particulars and forms of application may be obtained from the Registrar, Bradford Institute of Technology, Bradford, 7.

HENRY PATTEN,
Clerk to the Governors.

E5759

BUILDING RESEARCH STATION (D.S.I.R.)

GARSTON, NR. WATFORD, HERTS

CIVIL OR STRUCTURAL ENGINEERS AS SCIENTIFIC/SENIOR SCIENTIFIC OFFICERS

Building Research Station (D.S.I.R.), Garston, Nr. Watford, Herts., requires CIVIL OR STRUCTURAL ENGINEERS AS SCIENTIFIC/SENIOR SCIENTIFIC OFFICERS for research on concrete construction for nuclear power stations, design of multi-storey buildings, lightweight reinforced concrete, ultimate strength design, earth retaining structures, earth pressures on tunnels, and other projects in structural and civil engineering. Work involves laboratory studies up to model scale and field measurement on actual structures, all with first class facilities. Qualifications : 1st or 2nd Class Honours degree in civil or structural engineering. For S.S.O. at least 3 years post-graduate experience and minimum age 26. Salary ranges (men) S.O. £690 to £1144. S.S.O. £1250 to £1540. Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting E.340/OA. Closing date 16 September, 1960. E5750

SCIENTIFIC CIVIL SERVICE

(A) SENIOR SCIENTIFIC OFFICERS (B) SCIENTIFIC OFFICERS

The Scientific Civil Service needs men and women for pensionable posts as (a) SENIOR SCIENTIFIC OFFICERS, and (b) SCIENTIFIC OFFICERS in all major scientific fields, including

PHYSICS
ENGINEERING
CHEMISTRY
METEOROLOGY
MATHEMATICS and
BIOLOGICAL SUBJECTS.

Age limits : (a) at least 26 and under 32 ; (b) at least 21 and under 29. Extension for regular Forces service and Overseas Civil Service. Qualifications : normally first or second class honours degree in science, mathematics or engineering, or equivalent attainment ; additionally for (a), at least 3 years' relevant (e.g. post-graduate) experience. Selection by interview. London salaries (men) : (a) £1330 to £1640 ; (b) £730 to £1205 ; provision for starting pay above minimum. Promotion prospects. Write Civil Service Commission, 17 North Audley Street, London, W.1, for application form, quoting (a) S/53/60 ; (b) S/52/60. E5749

PUBLIC APPOINTMENTS

ADMIRALTY

ROYAL NAVAL SCIENTIFIC SERVICE

SENIOR SCIENTIFIC OFFICERS AND SCIENTIFIC OFFICERS

Royal Naval Scientific Service require SENIOR SCIENTIFIC OFFICERS AND SCIENTIFIC OFFICERS in establishments in following locations: London Area, Haslemere, Baldock, Poole, Cheltenham, Portland, Portsmouth.

Applications invited from graduates and post-graduate research workers with the following interests :

PHYSICS (classical, mathematical and electronic) ; ELECTRICAL ENGINEERING (electronic, telecommunications and radio) ; MATHEMATICS (pure and applied) ; HYDRODYNAMICS, MECHANICAL ENGINEERING (including servo-mechanisms, gyroscopes and welding development) ; CHEMISTRY (ceramics with solid state properties).

Candidates must normally be natural born British subjects of natural born British parents, with First or Second Class Honours Degrees or equivalent qualifications. S.S.Os must have had three years' post-graduate experience and be not less than 26 years of age. Salaries (men) S.S.O. £1330 to £1640; S.O. £730 to £1205 (London), somewhat lower in provinces. Appointments unestablished (with F.S.S.U. benefits), but opportunities may occur for those between ages of 21 and 32 to compete for established posts. Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting Order No. A.359/OA. E5754

CITY OF BIRMINGHAM SALVAGE DEPARTMENT

APPOINTMENT OF DEPUTY CHIEF ENGINEER

Applications are invited for the post of DEPUTY CHIEF ENGINEER in the above Department at a salary within the range £1220 to £1375.

Candidates must be Corporate Members of the Institution of Mechanical Engineers, and the person appointed will be responsible for the installation and maintenance of the mechanical and electrical plant at the various Refuse Disposal and Salvage Works of the Department.

Full details of the appointment may be obtained from the undersigned, to whom completed applications must be delivered not later than MONDAY, 12th SEPTEMBER, 1960.

ALAN E. BARTON,
General Manager.

Civic Centre,
Broad Street,
Birmingham, 1. E5592

MANCHESTER CORPORATION WATERWORKS UNDERTAKING

DEPUTY ENGINEER AND MANAGER

Applications are invited for the appointment of DEPUTY ENGINEER AND MANAGER of the Manchester Corporation, Waterworks Undertaking. Applicants should be Civil Engineers with administrative experience, preferably having a wide experience of the design and construction of large civil engineering works for water supply.

Commencing salary £2753 per annum, rising by annual increments of £90 to £3023 per annum.

Details of appointment and application forms (returnable by 26th September, 1960) from the Secretary, Waterworks Department, Town Hall, Manchester 2. E5758

MIDDLESEX COUNTY COUNCIL

HEATING ENGINEERS OR DRAUGHTSMEN

HEATING ENGINEERS OR DRAUGHTSMEN required to assist in the preparation of interesting schemes for heating Public Buildings :

A.P.T. III : £880 to £1065, plus London Weighting £45.

A.P.T. II : £765 to £880, plus London Weighting up to £40.

Established, pensionable—five-day week. Prescribed conditions. Application forms (s.a.e.) from the County Architect, 1, Queen Anne's Gate Buildings, Dartmouth Street, S.W.1, returnable by 5th October. (Quote E.215 E). E5764

PUBLIC APPOINTMENTS

SOUTH AUSTRALIAN GOVERNMENT

APPOINTMENTS

Applications are invited for appointments in the following professions in the Government Service of South Australia :

	Salary ranges
ENGINEERS, CIVIL	£A1170 to £A1920
DRAUGHTSMEN, STRUCTURAL	£A1340 to £A1525

Commencing salaries within these ranges according to qualifications and experience.

First-class passages provided for selected applicants and families.

Good leave conditions (Recreation, Sick and Long Service).

Superannuation Fund available.

Houses on a rental basis provided.

Full information from :

Agent General for South Australia,
50 Strand,
London, W.C.2.
WHItehall 7471. E5692

UNITED BIRMINGHAM HOSPITALS

THE GENERAL HOSPITAL

ASSISTANT ENGINEER

Applications are invited for the post of ASSISTANT ENGINEER at the General Hospital (363 beds) and the Jaffray Hospital (54 beds). Salary £570 to £700 per annum, conditions of service as laid down by P.T.B. Whitley Council.

Applicants should be thoroughly experienced in the maintenance of steam boiler plants, heating and electrical services, &c. The possession of a recognised engineering certificate would be an advantage.

Applications, stating age, experience and qualifications, together with the names and addresses of two referees should be sent immediately to the House Governor, General Hospital, Steelhouse Lane, Birmingham, 4. E5729

CENTRAL ELECTRICITY GENERATING BOARD

ASSISTANT ENGINEER

ASSISTANT ENGINEER required in the Standards Section of the Design and Construction Department at Headquarters, London, S.E.1.

The successful candidate will be concerned with standardisation of plant and equipment. Experience of standards work, such as in large processing industry, and in the handling of plant spares, with knowledge of commodity coding, is essential. Candidates should have Higher National Certificate in Mechanical or Electrical Engineering or equivalent, and have had a sound technical and workshop training. Drawing Office experience would be an advantage.

Salary within the range £1450 to £1890 p.a.

Applications stating age, qualifications, experience, present position and salary, to the Personnel Officer, 24-30, Holborn, London, E.C.1., by 13th September. Envelopes should be marked "Confidential Ref. ENR/314." E5768

PRISON COMMISSION

CIVILIAN INSTRUCTIONAL OFFICER GRADE III FOR VOCATIONAL TRAINING

CIVILIAN INSTRUCTIONAL OFFICER, GRADE III, FOR VOCATIONAL TRAINING in Precision Engineering and Instrument Making. Post at H.M. Borstal, Gaynes Hall, Great Staughton, Huntingdon, for man age at least 30 years on 23 September, 1960.

Qualifications : Full apprenticeship plus at least 5 years' practical experience; City and Guilds (or equivalent) Certificate and some teaching experience desirable.

Provincial salary scale £930 to £1000. Prospects of pensionable employment. 44-hour week and holidays with pay. Quarters not provided.

Write Prison Commission, R305/251, Horseferry House, Dean Ryle Street, London, S.W.1, for application form.

Closing date 9th September, 1960. E5753

Classified Advts, continued on page 104

PUBLIC APPOINTMENTS

CENTRAL ELECTRICITY GENERATING BOARD

SOUTH EASTERN DIVISION

DIVISIONAL WORKSHOPS BASED AT CROYDON

FOREMAN

VACANCY NOTICE No. 176/60

A vacancy exists at Divisional Workshops, Croydon, for a FOREMAN.

Applicants should have served a recognised apprenticeship and have received a sound training in turning, milling and grinding, &c. A knowledge of plate work and modern methods of welding essential. It would be an advantage if applicants have had similar experience and control of labour with a manufacturer or large engineering workshop.

Conditions of Service in accordance with the National Joint Industrial Council, Schedule E, Grade 1, salary £915 per annum inclusive of London Allowance. Applications giving relevant details of experience, &c., should be forwarded to S. W. Puckey, Divisional Workshops, c/o Croydon "B" Power Station, Beddington Farm Road, Croydon, Surrey, to arrive by 5th September, 1960. E5739

CIVIL SERVICE COMMISSION

CIVIL, STRUCTURAL, AND PUBLIC HEALTH ENGINEERS

CIVIL, STRUCTURAL AND PUBLIC HEALTH ENGINEERS. Pensionable posts for men and women at least 25 and under 35 on 1st January, 1960 (extension for regular Forces service, Overseas Civil Service, established civil service and temporary Government service as Civil, Structural, or Public Health Engineer). Candidates must have achieved Corporate membership of an appropriate professional Institution or have passed examinations necessary for attaining such membership. Some posts require qualifications in certain subjects. Salary (men, London) £830 to £1125, according to age, rising to £1300. Promotion prospects. Write Civil Service Commission, 17 North Audley Street, London, W.1, for application form, quoting S/64-66. E5751

CITY OF BIRMINGHAM WATER DEPARTMENT

APPOINTMENT OF ASSISTANT ENGINEERS

Assistant Engineers required in New Works and Contracts and Distribution Sections. Candidates should be University Graduates in Civil Engineering or have passed sections I and 2 of the I.C.E. examination or have an exemption accepted by the I.C.E. Salary within Grade A.P.T. I (£630 to £785), II (£765 to £880) or Special Grade (£785 to £1070) according to qualifications and experience. Appointments permanent and pensionable, subject to medical examination. Canvassing disqualifies. Application forms from General Manager, Water Department, Council House, Birmingham, 3, returnable by 12th September, 1960.

E5741

TENDERS

LEE CONSERVANCY CATCHMENT BOARD

SADLERS MILL STREAM DIVERSION SCHEME

TENDERS are invited for the following works in the Boroughs of Edmonton and Enfield, in the County of Middlesex:

(a) Construction of about 600 linear yards of 5ft. 6in. diameter CULVERT in tunnel and about 275 linear yards of same in trench.

(b) Construction of about 325 linear yards of REINFORCED CONCRETE CULVERT of widths varying from 4ft. 6in. to 9ft. and height about 4ft., together with manholes and appurtenant works.

Copies of the Tendering documents may be obtained after 18th August, 1960, from the Board's Consulting Engineers, J. D. and D. M. Watson, M.M.I.C.E., 67, Tufton Street, Westminster, S.W.1, upon payment of a deposit of Ten Guineas, which will be returned only on receipt of a bona fide Tender and return of all documents. Cheques should be made payable to The Lee Conservancy Catchment Board. The Board does not bind itself to accept the lowest or any Tender.

No Tender will be considered unless received in the envelope provided (with no mark indicating the sender), sealed, and delivered to the undersigned by noon on 19th September, 1960.

J. D. SPILLER,
Clerk of the Board.

The Lee Conservancy Catchment Board,
Brettenham House,
Lancaster Place,
Strand, W.C.2. E5700

TENDERS

BIGGLESWADE WATER BOARD

ADDITIONAL SUPPLIES

CONTRACT NO. 6.— SUBMERSIBLE PUMPS

The Biggleswade Water Board invites TENDERS from qualified manufacturers for the SUPPLY and ERECTION of TWO SUBMERSIBLE PUMPS in boreholes. The supply of the associated switchgear is not included.

Tender documents may be obtained from the offices of the Engineers, Messrs. Binnie, Deacon & Gourley, Artillery House, Artillery Row, Westminster, London, S.W.1, on payment of a cheque for £10 made payable to the Biggleswade Water Board, which amount will only be refunded on receipt of a bona fide Tender.

Tenders in plain sealed envelopes endorsed "Tender for Pumps" must be delivered to my office before noon Tuesday, 13th September, 1960.

The Board does not undertake to accept the lowest or any Tender and will not defray any expenses in tendering.

W. M. HYDE,
Clerk to the Board.

23, London Road,
Biggleswade,
Beds. E5761

COUNTY BOROUGH OF BRIGHTON

WATER DEPARTMENT

PATCHAM PUMPING STATION

REMOTE AUTOMATIC CONTROL EQUIPMENT

FIXED PRICED TENDERS INVITED for the MANUFACTURE, DELIVERY, ERECTION, TESTING and SETTING IN OPERATION equipment for REMOTE and LOCAL AUTOMATIC CONTROL of Electrically Driven Submersible Well and Surface Booster Pumps.

Specification and Particulars from Chief Engineer, Water Department, 12 Bond Street, Brighton, on payment of Two guineas deposit to be refunded on receipt of a bona-fide Tender and return of all documents.

Tenders in plain sealed envelopes, endorsed REMOTE CONTROL, PATCHAM PUMPING STATION to be delivered to me by noon on 30th September, 1960.

The Corporation do not bind themselves to accept the lowest or any Tender.

W. O. DODD,
Town Clerk.

Town Hall,
Brighton. E5735

COUNTY BOROUGH OF BRIGHTON

WATER DEPARTMENT

PATCHAM PUMPING STATION CONTRACT NO. 4 STERILISATION PLANT

TENDERS invited for the MANUFACTURE, DELIVERY, ERECTION and SETTING TO WORK of STERILISATION EQUIPMENT at the above Pumping Station.

Copies of General Conditions of Contract, Drawings, Specification and Form of Tender obtainable from the Chief Engineer, 12, Bond Street, Brighton, 1. Deposit of £2 2s. will be refunded on receipt of a bona fide Tender and return of documents supplied.

Tenders enclosed in plain sealed envelopes not bearing any name or mark indicating the sender and endorsed "PATCHAM—CONTRACT No. 4—STERILISATION PLANT" must be delivered to me before noon on Friday, 30th September, 1960.

The Corporation do not bind themselves to accept the lowest or any Tender.

W. O. DODD,
Town Clerk.

Town Hall,
Brighton. E5737

INDIA SUPPLY MISSION

TENDER NOTICE NO. SE.234

The office of India Supply Mission, 2536 Massachussetts Avenue, N.W. Washington 8, D.C., United States of America invites TENDERS for the following:

TENDER NOTICE No. SE.234

	Nos.
DIESEL CRAWLER TRACTOR, 75-85 draw-bar horsepower compression	17
CRAWLER TRACTOR as above but with hydraulic bulldozer	40

Tender documents etc., relative to the above, can be obtained from the Co-ordination Branch, India Store Department, Bromyard Avenue, Acton, W.3, at a cost of 14 shillings and threepence per Tender, and is not refundable. Tenders are to be returned direct to India Supply Mission, 2536, Massachussetts Avenue, N.W. Washington 8, D.C., United States of America, so as to reach them by the 13th October, 1960.

Specimen copy of the above enquiry can be seen at India Store Department, Vehicles Branch, Bromyard Avenue, Acton, W.3, under the following reference: S.3503/60/AKB/VEH. E5763

TENDERS

COUNTY BOROUGH OF BRIGHTON

WATER DEPARTMENT

SEVENDEAN RESERVOIR

TENDERS invited from Experienced Contractors for the CONSTRUCTION of a 1½ million gallon REINFORCED CONCRETE RESERVOIR and ANCILLARY WORKS at Bevendean, Brighton.

Specification, Bill of Quantities and Contract Documents obtainable from Chief Engineer, 12 Bond Street, Brighton. Deposit of £5 5s. will be refunded on receipt of a bona fide Tender and return of documents supplied.

Tenders enclosed in plain sealed envelope not bearing any name or mark indicating the sender and endorsed "TENDER for BEVENDEAN RESERVOIR" to be delivered to me before noon on Friday, 30th September, 1960.

The Corporation do not bind themselves to accept the lowest or any Tender.

W. O. DODD,
Town Clerk.

Town Hall,
Brighton. E5736

N.A.T.O. COMMON INFRASTRUCTURE SLICE VIII

NAVAL BASE INSTALLATIONS

Preliminary Notice is hereby given that International Competitive Bids will be INVITED early in 1961 for the CONSTRUCTION of a P.O.L. STORAGE DEPOT in the U.K.

The works include Storage Tanks totalling about 150,000 cubic metres, Pipelines, Jetty, Hose HANDling Appliances, Pumping Plant, Steam Heating and Electrical Services.

2. A further Notice will be issued and will provide details enabling Contractors to indicate their desire bo bid. Enquiries regarding Bidding, Specifications and Conditions of Contract should not be made until this further Notice is issued.

Admiralty, S.W.1. E5744

EDUCATIONAL

THE COLLEGE OF AERONAUTICS

A SHORT COURSE ON
AIRCRAFT GAS TURBINE THEORY AND DESIGN
will be held at the College from
Monday, 7th November to
Friday, 25th November, 1960
and will be repeated from
Monday, 6th March to Friday, 24th March, 1961

The course will deal mainly with performance, systems, turbomachine aerodynamics and related design topics, but will include some experimental work on engines.

Fees for the course are £70 inclusive of full board and residence.

Further details and forms of enrolment may be obtained on application to the Warden, The College of Aeronautics, Cranfield, Bletchley, Bucks.

E5760 E

A.M.I.MECH.E., B.SC., City and Guilds, &c. Guarantee Postal Courses for all Exams. and Technical Divisions from Elementary to Degree standard including Automation Techniques. Approximately 95 per cent. successes. 148-page, prospectus, free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. B114 E

UNIVERSITY OF MANCHESTER

THE NEXT SESSION COMMENCES ON TUESDAY, 11th OCTOBER, 1960. E5723 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES NOT ORIGINALS OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

ASSISTANT WORKS ENGINEER wanted for large modern synthetic resin factory near Newport, Monmouthshire. Applicants should be aged 23-30 and must have served an apprenticeship and had drawing office experience; minimum standard of education H.N.C. Salary £900 to £1250, according to experience and qualifications. The position offers good prospects of promotion. Contributory life assurance and pension scheme.—Write details of education and experience to BOX No. E5773, "The Engineer." A

DRAUGHTSMAN with design experience required for work on varied research projects and detailing of plant and equipment mainly of a medium and light engineering nature. H.N.C. Mechanical Engineering. Salary not less than A.E.S.D. rates. Pension Scheme. Five-day week. Hours 9.00 a.m. to 5.15 p.m. Staff Canteen.—Applications in writing to the Administration Officer, The British Iron and Steel Research Association, 140, Battersea Park Road, London, S.W.11. Tel.: MAC 5511. E5727 A

DRAUGHTSMAN DESIGNER required for Equipment Department (responsible for new layouts, &c., in various parts of Fort Dunlop factory.) The work covers mechanical handling and/or design of automatic and semi-automatic machinery for rubber processing and tyre manufacture. (Rubber experience not essential but applicants should know something about mechanical handling and/or special-purpose machine design in other industries.) Holiday arrangements respected. Pension scheme; five-day week; excellent working conditions. Age range: 25-43.—Please write, giving brief details and commencing salary required, to Staff Officer (Reference E), Employment Department, Fort Dunlop, Erdington, Birmingham, 24. E5641 A

SITUATIONS VACANT

DESIGNER/ENGINEER required to assist in the development of new mechanisms. Applicants must have served a practical apprenticeship and may be either mechanical engineers with some electrical knowledge or electrical engineers with strong mechanical associations. They should be qualified to G.I.Mech.E. or G.I.E.E. standards. The successful applicant will essentially possess a flair for mechanisms and be able to think in three dimensions. Salary according to experience in the range £1000 to £1500 p.a. Preferred age group 25 to 35.—Applications, giving details of qualifications and previous experience should be addressed to W. J. Fraser & Co. Ltd., Romford, Essex. Ref.: DEV/GTK. E2979 A

ENGINEER required for inspection of Lifting Tackle in South Essex. Must have served Engineering apprenticeship. Drawing office experience desirable. National Certificate in Mechanical Engineering an advantage. Knowledge of manufacture and maintenance of Lifting Tackle essential.—Write Box E771, LPE, Romano House, 399-401, Strand, London, W.C.2. E5769 A

ENGINEER (about 30 years) required for Consulting Engineers' Office in Manchester; Engineering degree and/or corporate membership of a major engineering Institution; varied industrial experience an advantage. Technical investigation and reports in matters where litigation is being considered.—BOX No. E5644, "The Engineer." A

ENGINEERS, DRAUGHTSMEN, and all Technical staff, are invited to forward details of qualifications, etc., to Abbatt Technical Division, who will handle and negotiate on their behalf, without charge, any change of employment contemplated. Leading Organisations consult Abbatt, 25, Kensington High Street, W.8. WES. 0768-9. E2963 A

ENGINEERING INSURANCE. Applications are invited from Mechanical Engineers not over 35 years of age, who having served an apprenticeship with Crane and Lift Makers have a sound theoretical and practical knowledge of Cranes, Lifts, Lifting Machines and their maintenance, and are qualified to Higher National Certificate Standard, for a vacancy as ENGINEER SURVEYOR based in the Stoke-on-Trent district. The position is permanent, pensionable, with salary scale of £800 rising to £1100 per annum, plus expenses and allowances. —Apply in own handwriting to BOX No. E5660, "The Engineer." A

ESTIMATING ASSISTANT for London office of large North country Engineering concern. Applicants should hold O.N.C. or preferably H.N.C. and be age 22 or over. Full details of past experience and present employers should be stated in strict confidence to BOX No. E5730, "The Engineer." A

GRADUATES IN MECHANICAL ENGINEERING

(B.Sc. or equivalent)
An old-established Engineering Firm has vacancies for Graduates for training as PROJECT and RESEARCH ENGINEERS
Applications to Secretary,
MUSGRAVE & CO., LTD.,
ST. ANN'S WORKS, BELFAST. 5.
E2982 A

LARGE MIDLAND BREWERY REQUIRES A DESIGN DRAUGHTSMAN experienced in plant layouts and structural work. Minimum qualification H.N.C.—Apply, stating qualifications and salary to the Chief Engineer, Ansells Brewery Ltd., Aston Cross, Birmingham, 6. E2981 A

MECHANICAL, ELECTRICAL AND CIVIL ENGINEERS required by North Eastern engineering office dealing with industrial power plants and electrification schemes. The applicants, who should be aged between 28 and 35 years, should be keen and able to work with minimum supervision. Minimum qualification is H.N.C., together with good experience in Thermal Plant/Electrical design layout and the ability to handle Contract work. Contributory Superannuation Scheme.—Reply, giving full details of age, experience and present salary to BOX No. E5674, "The Engineer." A

MECHANICAL ENGINEERING DRAUGHTSMAN required by John Smith's Tadcaster Brewery Co. Ltd., The Brewery, Tadcaster, Yorkshire. Of good general education, and of H.N.C. or higher standard, and sound practical apprenticeship in a modern engineering works. At least two years Drawing Office experience essential, preferably on food, chemical or allied plant, pipe work, pumps, vessels and steam utilisation. Applicants must be able to pass medical examination and be of active and energetic character. Good starting salary with annual increments if satisfactory. Voluntary pension scheme in operation, canteen and sports facilities. Reply to Chief Engineer, stating age and qualifications, education, apprenticeship, and positions held, in chronological order. Expenses will be paid to those selected for interview. E5676 A

PORT OF MANCHESTER ENGINEERING APPOINTMENT

Applications are invited for a Senior position on the staff of the Chief Engineer.

The position is one which offers excellent prospects of promotion and will carry a salary commensurate with the responsibilities entailed.

Candidates, who must be Corporate members of the Institution of Civil Engineers, should not only have extensive experience in dock and harbour construction and maintenance but should also have first class executive and administrative experience.

The successful candidate will be required to pass a medical examination and to become a member of the Company's Contributory Superannuation Scheme.

Applications, stating age, qualifications and full details of experience, should be addressed to the Chief Engineer (marked "Personal"), The Manchester Ship Canal Company, Ship Canal House, King Street, Manchester, 2, not later than the 30th September, 1960. E5733 A

SITUATIONS VACANT

PLANT ENGINEER—A company of ironfounders and heating and cooking appliance makers in Central Scotland require the services of an Engineer to take charge of plant installation and maintenance both mechanical and electrical. The appointment gives the prospect of advancement, is pensionable and carries a salary of around £1250 per annum.—Particulars of qualifications and previous administrative experience to BOX No. E5755, "The Engineer." A

PUBLICITY ASSISTANT
required by
BRUCE PEEBLES & CO LIMITED, EAST PILTON, EDINBURGH, 5.

Applicants should have experience in technical journalism and ability to write lucid descriptions of engineering products and processes for publicity, press and other purposes, and be conversant with advertisement layout. The successful applicant would be required to write for, and edit, a Works magazine.

The Company manufacture heavy electrical plant and industrial electronic equipment and experience in those fields would be an advantage.

Full details, in confidence, of age, education, training, experience and salary required to Mr. J. S. Baillie, Publicity Manager, at above address.

E5652 A

RESEARCH AND DEVELOPMENT ENGINEERS

In order to meet a continuously expanding Design Development and Research programme, applications are invited for appointments as Research and Development Engineers. Candidates should be well qualified technically with knowledge and experience in one or more of the following fields :—

(1) Private and Commercial Body Engineering.

(2) General Mechanical Engineering.

(3) Process Engineering (Plastics, Dust and Water Sealing, Dielectric Welding).

(4) Hardware and Interior Trim Engineering.

The project programme is varied and includes investigation of new manufacturing processes, equipment, materials and their application to Motor Cars, Commercial Vehicles and other products without regard to the conventional.

These openings offer the opportunity for those with experience in the above-mentioned fields to join an expanding Organization. Conditions of employment accord with best industrial practice. Applications with full details of education, training, experience and salaries earned may be made to the Staff Officer, Pressed Steel Company Limited, Cowley, Oxford, where the appointments will be located. E5752 A

SENIOR PIPELINE ENGINEER required for service in Iran to advise on Pumping Station Operations (Diesel and Electric) for Gasoline, Kerosene and Natural Gas through 10in. lines. Two-year contracts.—Apply : National Iranian Oil Company, 132-5, Sloane Street, S.W.1. E2978 A

SITE CONSTRUCTION ENGINEER required in the age group 30-50 years. Several years' experience of site work essential, particularly with respect to the handling of both skilled and unskilled labour. The work will involve both civil and mechanical engineering and the applicant should have some drawing office experience so that he can read construction drawings and keep to erection programmes. The work will be in the Widnes area and will involve the supervision of the construction of chemical plants. The starting salary will be based on age and experience.—Applicants should write in confidence, giving details of experience, to Project Engineer, Forestal Land, Timber & Railways Company Ltd., Ditton, near Widnes, Lancs. E5640 A

STRUCTURAL STEELWORK DESIGNER required conversant with modern welded construction and B.S.S.449. Salary commensurate with experience and qualifications. First class prospects for the right man.—Apply to : G. R. Turner Limited, Langley Mill, Nottingham. E2977 A

SITUATIONS VACANT

TECHNICAL AUTHOR required, not over 45, to assume responsibility for the compilation of operating and maintenance instruction manuals dealing with the Company's machinery. This interesting and progressive pensionable staff position would appeal to a suitably qualified Mechanical Engineer with a bias towards technical writing.—Applications should be addressed to the Personnel Manager, Molins Machine Co. Ltd., Evelyn Street, London, S.E.8.

E5590 A

THE GENERAL ELECTRIC COMPANY LTD., Atomic Energy Division has a vacancy in the Reactor Heat Transfer Section for an ENGINEER having experience in the experimental techniques and theoretical work associated with vibration studies.

The engineer appointed will work in a small team and will be responsible for initiating and supervising the experimental work.

Applicants having Ph.D. or M.Sc. training or at least two years' experience in this field will be considered for the position. A knowledge of fluid flow would be an additional advantage.

Apply Personnel Manager (DWB/25), The General Electric Company, Ltd., Erith, Kent. E5756 A

WESTERN REGION OF BRITISH RAILWAYS require ENGINEERING ASSISTANTS (capable of supervising Drawing Office staff) and TECHNICAL ASSISTANTS experienced in the design of reinforced concrete and steel bridges and other structures to fill vacancies in posts in the salary ranges £1095 to £1150 and £875 to £948 respectively. Interesting work in pleasant conditions with promotion on MERIT ; Superannuation Fund ; reduced rates of travel and other concessions ; 5-day week.—Applications, giving age, qualifications and experience, to : Chief Civil Engineer, British Railways, Western Region, Paddington Station, London, W.2. E5722 A

WESTERN REGION OF BRITISH RAILWAYS require : TECHNICAL ASSISTANTS to examine and assess the strength of existing girder bridges and structures, and to prepare site surveys ; salary range £875 to £948. Interesting work in pleasant conditions with promotion on MERIT ; Superannuation Fund ; reduced rates of travel and other concessions ; 5-day week.—Applications, giving age, qualifications and experience, to : Chief Civil Engineer, British Railways, Western Region, Paddington Station, London, W.2. E5721 A

WORKS MANAGER required for Agricultural Engineering Works in East Anglia. Must have knowledge of Batch Production of Machines and Management of Men. Staff now about 40. Housing accomodation available. Salary according to qualifications and experience.—Reply in confidence giving Age, Qualifications and Experience to BOX No. E5467, "The Engineer." A

WANTED for a British controlled Company in South India engaged in the Textile and Engineering Industries, and in General Trading :

(1) A DEPUTY CHIEF ENGINEER
Candidates for this appointment should be highly qualified Electrical Engineers, not more than 40 years of age, with experience in handling large Power Generation Contracts. Qualifications, or experience in general Mechanical and Structural Engineering and Works Control are desirable and would be a considerable advantage.

(2) A DESIGN AND CONTRACTS ENGINEER
Candidates for this appointment, who should be between 30 and 40 years of age, should have considerable experience in the design and layout of modern Sugar Factories complete with Boiler Plant, Centrifugal Station, piping arrangements, etc., A.M.I.Mech.E. or similar qualification is desirable and knowledge of Chemical Engineering would be an advantage.

(3) A MACHINE SHOP SUPERINTENDENT
Candidates for this appointment, between 30 and 40 years of age, should have sound and varied practical and technical experience to enable them to take charge of light and medium/heavy Machine Shops working on plant and products for a wide range of industries. They should have held a position of Superintendent or Foreman for a period of not less than 5 years.

Good salaries on rising scales are offered according to the age and capabilities of the applicant. Free furnished quarters are provided, free medical attention for employees and wives, retiring benefits, home leave and free passages including wives and children. The first contract is for a period of 3 years.—Write stating age, qualifications, whether married or single and details of any family to Box Z.S. 82, Deacons Advertising, 36, Leadenhall Street, London, E.C.3. E5767 A

YOUNG MECHANICAL ENGINEER required as assistant to General Manager. The work which is varied and interesting includes specialised operations using large cranes, the manufacture of special equipment and technical investigations. The successful candidate will have served a sound practical training, including D.O., and will have obtained at least H.N.C. or B.Sc. Managerial prospects. South Yorkshire.—Full details, experience, including salary, BOX No. E5772, "The Engineer." A

BOOKS and PUBLICATIONS

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Telephone : CENtral 6565

SITUATIONS VACANT

THE REED PAPER GROUP

has a vacancy for an

ENGINEERING INSTRUCTOR

Applications are invited for the post of Engineering Instructor at the Works Training School, on Aylesford site, nr. Maidstone, Kent.

The successful applicant will be required to instruct young apprentices in basic Work Shop Practice and Theory in both fitting and machine tool work. The range of work covers Mechanical, Motor Vehicle and Instrument Engineering. It is anticipated that the successful applicant will not necessarily have a wide knowledge of all three subjects.

Previous experience with a variety of machine tools is essential. Applicants should hold at least an Ordinary National Certificate or Final City and Guilds qualification in Mechanical Engineering or its equivalent and should preferably be between 27 and 45 years of age.

Excellent conditions of service include a non-contributory pension scheme and assisted house purchase.

Applications in writing giving full details of education, experience and salary required, should be addressed to :

THE GROUP PERSONNEL OFFICER,
ALBERT E. REED & CO., LTD.,
LARKFIELD, NR. MAIDSTONE, KENT.

quoting reference EI/GE/71. E5733 A

SITUATIONS VACANT

DUBAI ELECTRICITY COMPANY
TRUCIAL STATES
PERSIAN GULF

APPOINTMENT OF CHIEF ENGINEER AND MANAGER

Applications are invited by the Dubai Electricity Company, Trucial States, for the position of Chief Engineer and Manager. Candidates should be qualified in Electrical Engineering and hold Membership of at least one of the Corporate Institutions, together with managerial and administrative experience. Commencing salary Rs 2,500 per month tax free and free furnished accommodation. Tours would be of two years' duration followed by three months' home leave. Air passages provided for wife and up to two children once in each contract period.

Applications, stating date of birth, qualifications and experience, together with names of three Referees, should be addressed to Reference R.F.S., Kennedy & Donkin, 12 Caxton Street, London, S.W.1., to arrive not later than September 16th, 1960.

E5606 A

CHEMICAL ENGINEERING WILTONS LTD.,

A subsidiary of
SIMON CARVES LTD.,

require a

CONTRACTS ENGINEER

who will prepare design, specifications and tenders for chemical plant and would eventually be required to see contracts through, the latter would entail liaison with clients. Candidates must be graduates or graduate/corporate members of the Institution of Chemical, Gas or Mechanical Engineers. Previous experience of process design work and/or the handling of contracts for large chemical plant is desirable. This post is permanent and pensionable; offers considerable scope and an attractive starting salary.

Send brief relevant details to

Staff & Training Division,
SIMON-CARVES LTD.,
Cheadle Heath, Stockport, Cheshire, quoting ref. VW. 85.

E5720 A

KELVIN & HUGHES LIMITED
BARKINGSIDE, ESSEX

Invite applications for the post of

ENGINEER

for experimental and development work in connection with C.R.T. Displays and Instruments incorporating Optical, Electromechanical and Pneumatic techniques.

Degree in Physics and Mathematics preferable, but applications from men possessing H.N.C. (Electrical, L.C.) would be considered.

Interesting post, progressive salary, contributory Pension & Life Assurance, Medical & Canteen services, Recreation facilities. Close to Tube Station.

Applications stating qualifications, experience, personal details and salary required to :

Personnel Manager,
KELVIN & HUGHES LTD.,
NEW NORTH ROAD, BARKINGSIDE, ESSEX.

E5738 A

Reed

THE REED PAPER GROUP

requires a

GRADUATE PHYSICIST

or

QUALIFIED ENGINEER

in the Process Section of the expanding Packaging Division Development Department. The work will be associated with printing techniques in all aspects of paper conversion and packaging.

The successful applicant would be between 30 and 45 years of age and should have considerable experience on printing machine processes. Knowledge of carton production methods, including the application of adhesives would be an added advantage.

Replies, which will be treated in strict confidence, should contain full details of career to date and should be addressed to :

The Group Personnel Officer,
ALBERT E. REED & CO. LTD.,
Larkfield, Nr. Maidstone, Kent, quoting reference GP/GE/PDDD/73.

E5762 A

Classified Advts. continued on page 106

SITUATIONS VACANT

ELECTRICAL ENGINEER

An important British Gold Mining Company in Ghana wishes to appoint an Electrical Engineer. The successful candidate will be responsible to the Chief Engineer for the maintenance of all electrical plant and machinery on the surface and underground and for the installation of all new electrical equipment. He should have experience in power generation and distribution and in the maintenance of records and ordering of spares. Previous Mining Engineering experience essential; technical qualifications at least up to H.N.C. (Electrical) standard.

STARTING SALARY NOT LESS THAN £1,750 per annum.

Tours abroad are for 15 months followed by 3 months' paid leave, passages and housing provided. The post is healthy and suitable for children. The appointment is permanent and pensionable. Income Tax at low local rates.

Applications, which will be treated in confidence should give details of technical training, practical experience and positions held and should be addressed to BOX No. E5734, "The Engineer." A

SITUATIONS VACANT

ENGINEER-DESIGNERS

wanted for

HEAVY INDUSTRIAL PLANT

Age group 30-45. Vacancies exist in our London Drawing Office in the following groups:-

(1) Structural. Steel framed buildings and bunkers.

(2) General Mechanical Equipment.

(3) Belt conveyor installations.

Good future prospects. 5 day week, 3 weeks' holiday, luncheon vouchers, and pension scheme. Write stating experience and qualifications to Staff Dept., Huntington, Heberlein & Co., Ltd., 28-29, Dover Street, London, W.1.

E5724 A

SITUATIONS VACANT

DRAUGHTSMEN

Draughtsmen are required at the Midlands Research Station, Solihull.

The duties are interesting and will include work on the design of pilot and prototype plant associated with the development of new high-pressure processes for the production of town gas.

Candidates should possess at least an O.N.C. certificate in Mechanical Engineering.

The salary for the appointments, which are pensionable and subject to medical examination will be within the range of £770-£1015 per annum.

Applications, stating age, education and experience, should be addressed to the Industrial Relations Officer,

WEST MIDLANDS GAS BOARD,

6, Augustus Road, Edgbaston, Birmingham, 15

E190 A

SITUATIONS VACANT

CENTRAL ELECTRICITY GENERATING BOARD

requires

SHIFT CHARGE ENGINEERS

AT PADIHAM POWER STATION, NEAR BURNLEY, LANCS.

The plant to be installed will consist of two B.T.H. turbines of 120MW operating at a steam pressure of 1500 lbs. per sq. ins. at an initial temperature of 1010 degrees F. reheat temperature 1005 degrees F. Two boilers of 860 k.lb./hr. capacity, pulverised fuel fired with slag tap furnaces.

Applicants should have H.N.C. in Mechanical and/or Electrical Engineering. This is an opportunity for engineers possessing drive, vision and initiative.

Salary within the range of £1440 to £1610 (K.6) and the post is superannuable. Standard application forms are not required, but applicants should set out their application in their own preferred form of presentation and quoting the names of two referees and forward to the Director of Labour and Welfare, Central Electricity House, 825 Wilmslow Road, Manchester 20, by 6th September, 1960. Please quote vacancy No. E.161/397/B. Previous applicants need not re-apply. E5745 A

QUALITY CONTROL

IN

LIGHT ENGINEERING

An opportunity has arisen for a qualified engineer who has specialised in all aspects of modern inspection and quality control techniques as applied to light mechanical (and some electrical and plastics) engineering products. This post of Chief Inspector calls for executive experience in this field, covering precision work as well as semi-mass production runs; academically, I.P.E. corporate membership or its equivalent is desirable; candidates must have a background of approval by Ministries and nationalised industries. Salary and other conditions will be commensurate with the post and with the successful candidate's qualifications and experience; prospects within the Group are attractive.

Write in the first instance, with all relevant details to:

THE WALLACE ATTWOOD COMPANY,
West Halkin House, West Halkin Street,
LONDON, S.W.1.

who are acting on behalf of the Company. No approaches will be made to present employers without the candidate's approval.

E5731 A

BABCOCK & WILCOX LIMITED

A vacancy exists in the *ATOMIC ENERGY DEPARTMENT* at London Office for a

MECHANICAL ENGINEER

to undertake design work on precision structures and mechanisms, including fuel elements, associated with the cores of water- and gas-cooled reactors.

The applicant should have an engineering degree or the equivalent, and recent experience of analogous design work, requiring familiarity with stress analysis techniques and knowledge of manufacturing methods.

Apply in writing to :

The Assistant Secretary,
209, Euston Road,
London, N.W.1.

E5742 A

WORK STUDY ENGINEERS

are invited to apply for vacancies that offer temporary engagements, at advantageous terms of 1 to 2 years duration, in a light Engineering factory situated in the Midlands.

The project involved is of importance and concerns review, re-study and implementation of Company Policy in the application of Work Study affecting several thousand employees.

Permanent posts will be available to some participants on completion of this project.

Applicants should write, quoting EG/M, stating age, qualifications and experience to The Personnel Manager, BOX No. E5593, "The Engineer." A

'ENGLISH ELECTRIC'

WHETSTONE NR. LEICESTER

ENGINEERS

PHYSICISTS

MATHEMATICIANS

1. The CONTROL SYSTEMS GROUP which is responsible for the analysis and initial design of closed loop control systems for reactors and conventional plant has a senior vacancy for a young graduate mechanical or electrical engineer, a mathematician with a knowledge of basic control theory. Experience of either reactor or steam turbine systems, together with a familiarity with analogue computer operation would be an advantage but is not essential.

2. The SAFETY SYSTEMS GROUP is concerned with the design of protection systems and analysis of transient behaviour of over all plant under abnormal conditions, and has a senior vacancy for a young graduate mechanical engineer preferably in the age group 25-32.

An opportunity also exists for a young graduate engineer, physicist or mathematician to gain the experience required for the above position, assisting a senior engineer in the preparation of complex analogue simulators involving the use of 200-250 amplifier computer units.

These are a few of the several vacancies available and general enquiries will receive favourable consideration.

The appointments are permanent and pensionable; the offices are situated in rural surroundings and assistance can be given with initial accommodation.

Enquiries giving details of age, qualifications, experience and current salary (which will be treated in strictest confidence) should be addressed to the **Technical Staff Officer, G.P.S., Marconi House, 336/7 Strand, London, W.C.2.**, quoting reference E1896N.

E5725 A

TECHNICAL ENGINEERS

are required by the Research and Development Branch at Risley for the Central Technical Services which is responsible for carrying out major calculations on nuclear reactor and other projects which are being undertaken by the Authority. The vacancies arise in a section concerned with fluid mechanics and engineering thermo-dynamics covering heat transfer in nuclear reactors and chemical apparatus, proportioning of heat exchangers, aerodynamic design of compressors, lubrication, the flow of liquids or gases through branched ductwork systems and steam power cycles. Detailed knowledge of these problems is less important than an interest in engineering science and a facility for applying it. A programming and computing service, both digital and analogue, is available in a parallel section of the organisation. Contact with the experimental work being carried out in the laboratories of the Branch is actively encouraged.

Applicants should have served a recognised engineering apprenticeship, be Corporate Members of a senior professional institution or have an honours degree in engineering, together with at least three years relevant industrial or research experience, or possess equivalent qualification.

Salary will be on the scale £1,880 to £2,180 or £1,370 to £1,825 according to age, qualifications and experience.

Contributory superannuation. Staff housing scheme.

Send postcard for application form, quoting reference 341/J1, to:

Senior Recruitment Officer,

UNITED KINGDOM ATOMIC ENERGY AUTHORITY,

(Development and Engineering Group Headquarters)
Risley, Warrington, Lancashire.

Closing Date: 12th September, 1960

E5719 A

SITUATIONS VACANT

INDIA, MADRAS DISTRICT,

ROLLING MILL ENGINEER SUPERVISOR,

to take charge of Cold Rolling Mill (Steel) and Auxiliary Plant including heat treatment. Must have experience of operating modern equipment. Initial contract for twelve months with renewal by mutual arrangement for further two years. Good salary and housing provided with first-class working conditions. Good opportunity for man with initiative who is willing to accept responsibility.—Apply BOX No. E5765, "The Engineer."

A

SITUATIONS VACANT

DRAUGHTSMEN AND DESIGNERS

Required by Crawley Industrial Products, Ltd., for their new factory at Llanelly.

Only engineers with plenty of drive and initiative need apply as the Company is starting on a major development and expansion programme.

Experience in the design of Underground Mining Machinery will be an advantage but not an essential qualification.

Designers to be within the age group 25-35 and to have H.N.C. as a minimum qualification.

Draughtsmen to be within the age group 21-30 and must possess at least the O.N.C.

Interested and sincere applicants only should apply stating age, experience, qualifications and salary to :

CRAWLEY INDUSTRIAL PRODUCTS, LTD.
46/48 Wellesley Road, Croydon, Surrey.

E2983 A

SITUATIONS VACANT

PLANT ENGINEERS

JOSEPH LUCAS LIMITED

have vacancies for Plant Engineers in the Works Engineering Department, who will be responsible for the maintenance of plant and equipment at the Company's Factories, together with the installation of services and plant in new buildings. Men with initiative and the ability to lead and control will find the work stimulating and satisfying, and opportunities exist for promotion to senior levels in the department.

Applicants should be between 30 and 45 years of age and, in addition to industrial experience, should be in possession of engineering qualifications. The posts are permanent and pensionable and a good starting salary will be paid according to qualifications and experience.

Apply in writing, stating age, qualifications and experience, to the:

Personnel Manager,
JOSEPH LUCAS LIMITED, Great King Street, Birmingham, 19,
quoting reference PM/WE/500.

E5747 A

REAVELL-FAHIE LIMITED

Reavell-Fahie Limited requires the services of two

GRADUATE ENGINEERS OR PHYSICISTS

for staff duties at Ranelagh Works, Ipswich

The company, a subsidiary of Reavell & Co., Ltd. was formed to take over, develop and expand the parent company's interests in the field of automatic control and instrumentation in heavy industry. Since 1927, the parent company has exploited the well known Reavell Askania hydraulic controller, which is capable of further development to be undertaken by Reavell-Fahie in this country in collaboration with its associates in the U.S.A.

One of the chosen applicants will be appointed as personal assistant to the Managing Director, with special reference to technical sales. The other will be appointed as personal assistant to the Director responsible for Production and Development.

Both are positions of trust and responsibility and appropriate salaries will be paid.

Applications will be treated in confidence and should be addressed to the Managing Director Reavell-Fahie Ltd., Ranelagh Works, Ipswich, Suffolk.

E5728 A

SIMON-CARVES LTD.,

have a vacancy in the

TECHNICAL SECTION

of their

POWER PLANT DEPARTMENT

for

AN ENGINEER

Applicants must have some experience of thermodynamic calculation. Knowledge of boiler plant is desirable. Full consideration will be given to applicants with H.N.C. (Mech.), but those with a degree or A.M.I.Mech.E., will be preferred. This post is permanent and pensionable. The starting salary will depend on experience and qualifications. Good working conditions.

Send brief relevant details to Staff & Training Division, **SIMON-CARVES LTD.**, Cheadle Heath, Stockport, Cheshire, quoting Ref. UC.5.

E5746 A

AEI

A.E.I./DAVY-UNITED STEELWORKS AUTOMATION UNIT

DAVY-UNITED

The Steelworks Automation Unit has been formed jointly by Associated Electrical Industries and Davy-United to apply the most advanced techniques of automation within the steel industry. The work involves development and design in the forefront of the rapidly-growing fields of industrial computers, data handling, and self-optimising control systems.

Engineers, physicists and mathematicians of high calibre are needed for this work, and there are vacancies for such men, with or without experience in the steel industry, in the fields of:

Control and Data Handling	Operational Research
Digital Computer Techniques	Mathematical Analysis
Instrumentation	Computer Programming

If you want to join a new and exciting venture which will provide you with real satisfaction, and excellent prospects in an expanding field of endeavour, write to the address below for an interview, giving a summary of your academic attainments, practical training and experience, and brief personal details.

Ref. WS/SAU,

AEI/Davy-United Steelworks Automation Unit,
Mill Road, Rugby, Warwickshire.

E5726 A

ICI

METALS DIVISION - RESEARCH

A

MECHANICAL ENGINEER

is required to lead a research team engaged in the field of the plastic deformation of a wide range of metals, which include titanium, zirconium, beryllium, and other industrially new metals. Processes include rolling extrusion, pressing and drawing. The work is primarily investigational and involves the full range from short term assistance to the mills to fundamental investigations aimed at increasing understanding of the processes used. Some design of instruments and small scale and prototype plant is also involved.

Excellent semi-technical scale equipment is available. The post also includes responsibility for a machine shop and small drawing office which serve the Division Research Department as a whole.

Candidates, preferably in the age range 30/40, should have an honours degree in engineering and have undertaken either university or industrial research. They should also have some knowledge of the subject of plasticity or of some part of the metallurgical industry.

There is a good starting salary, dependent on age and experience with excellent prospects of advancement. The appointment is pensionable and there is a profit-sharing scheme in operation. Assistance can be given to a married man towards house purchase and removal expenses.

Please write for an application form to the Assistant Personnel Manager (Staff), IMPERIAL CHEMICAL INDUSTRIES LIMITED, Metals Division, P.O. Box 216, Kynoch Works, WITTON, Birmingham 6. quoting RES/438/E.

E5740 A

Classified Advts. continued on page 108

SITUATIONS VACANT

Another Opportunity in Iron and Steel

BISRA

The Association has a vacancy for a

GRADUATE CIVIL or MECHANICAL ENGINEER

in its Engineering Laboratories in London. The research, which is varied and interesting, is particularly directed to solving special structural problems in the steel industry by the application of modern techniques of design and stress measurement. An Honours degree in civil or mechanical engineering is preferable but not essential. Some experience of stress measuring techniques together with some knowledge of framed structures and their foundations would be an advantage. The successful applicant will be able to publish the results of his research.

Starting salary up to £1,080, according to age, qualifications and experience. The post is superannuated under the F.S.S.U.

Written applications only, quoting E18, to the Personnel Officer, The British Iron and Steel Research Association, 11, Park Lane, London, W.1. E5770 A

SITUATIONS WANTED

ENGINEERING MANAGER.—Chartered Mechanical Engineer, 15 years Supervisory and Management experience in Design, Development, Project and Product Engineering, 8 years in North America. Recently returned to this country, immediately available and prepared to locate in any district. Seeking challenging executive post requiring initiative and responsibility. Experienced in Mechanical, Hydraulic, Light Structural and Sheet Metal Industries; jobbing, batch and mass production techniques. Proven administrative capability.—BOX No. E2961, "The Engineer." B

SALES MANAGER—Home and Export Mechanical Electrical Engineer age 40 years requires change London area or Home Counties.—BOX No. E2983, "The Engineer." B

DRAWING & DESIGN SERVICE

GLENDEN TRACING AGENCY. Tel. Hornchurch 40254. Speed and accuracy assured by experienced Tracers. Terms moderate.—60, Hazelmere Gardens, Hornchurch, Essex. E2984 S

PATENTS

THE PROPRIETOR of British Patents Nos. 711299 and 711298, entitled "A GATE VALVE WITH AN IMPROVED BONNET AND SEALING MEANS THEREFOR," and "IMPROVED PLUG CLOSURES FOR HANDHOLES AND LIKE OF PRESSURE VESSELS," offers same for licence or otherwise to ensure practical working in Great Britain.—Inquiries to Singer, Stern and Carlberg, 140 South Dearborn Street, Chicago 3, Illinois, U.S.A. E5743 H

SUB-CONTRACTING

KELLERING AND CAM PROFILING capacity up to 8ft by 6ft or 6ft diameter.—ARMYTAGE BROS. (KNOTTINGLEY), Ltd., The Foundry, Knottingley, Yorkshire (Telephone: Knottingley 2743/4). E116 MW

BUSINESSES and PREMISES

GATESHEAD

Modern factory.

Approximately 21,000 square feet.

All modern services.

Internal height 20 feet.

Prominent position.

Details:

KNIGHT, FRANK & RUTLEY,

20 Hanover Square, W.1.

Telephone: MAY 3771.

E5638 L

MISCELLANEOUS

DEVON AND CORNWALL. Accommodation booked anywhere at immediate notice from 7 gns., plus 2 gns. booking fee.—Write or 'phone Carol Robinson Bureau, Morley Street, Plymouth. Telephone No.: Plymouth 62646. E5552 I

MOBILE LIFTING SERVICE. Lump Sum or Hire Rate quoted for any lifting work by Lorry-Mounted or Crawler Cranes, any size, any area.—TARSLAG, LTD., Rotherham 78481. E186 I

MISCELLANEOUS

BOOK KEEPING.—A. Davis & Co., Professional Book-keepers, write up business books, P.A.Y.E., &c. London and Provinces.—Write to 30, The Wool Exchange, Coleman Street, London, E.C.2. E2985 I

DAVIES INVESTMENTS LIMITED

BANKERS

(Gross assets £2,000,000), are paying 7½ per cent. p.a. interest on deposits for the seventh year in succession, with ½ per cent. added annually on each £500 unit.—Details and Audited Balance Sheet from: Investment Dept. ER.

DAVIES INVESTMENTS LTD.,
DANES INN HOUSE, 265 STRAND,
LONDON, W.C.2.

E178 I

MACHINERY Etc. WANTED

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By Order of the Secretary of State for War

GOVERNMENT SURPLUS STORES

SALES BY AUCTION

		Main Location	*Auctioneers*
September 6-7	Machine tools and miscellaneous stores including:—	M.O.A. Storage Depot, Royal Arsenal, Woolwich, London, S.E.18.	FULLER, HORSEY, SONS & CASSELL, (Dept. L), 10, Lloyd's Avenue, London, E.C.3. (Tel.: Royal 4861).
	Horizontal boring machines by Kearns and Richards; Swift Summerskill and Stirk motorised planing machines; Turret Capstan and S.S. & S.C. lathes; Vertical and Horizontal milling machines; Surface, Cylindrical and Universal grinders; Slotting machines; Rifling and Broaching machines; 2 Barber Greene Twin Aggregate Dryers, 14 Barber Greene Tar Macadam Dryer, Soil Preparation and Mixer Plants; 20 tons miscellaneous Locomotive Hand Tools; Diesel and Petrol driven Generating Sets and Power Units; Petrol driven Compressor Sets, Fork Lift Trucks; Pumping Sets, Electric Motors, 1100 12-ton and 15-ton Ratchet Jacks, Pneumatic tyred trailers, Rubber Outer Covers, M.T. Spares, 3,500 pairs Binoculars; Radar and Radio Scrap, Aircraft, Radio and Electrical Stores, miscellaneous Hand tools, Drawing Instruments, Scrap Batteries, Rope, Canvas and numerous other effects.		
September 13	Miscellaneous stores.	No.1 E.S.D., Long Marston, Nr. Stratford-on-Avon, Warwicks. (Sale at the Hippodrome, Stratford-on-Avon).	LOCKE & ENGLAND, (Dept.L), 166, Parade, Leamington Spa, Warwicks. (Tel.: 2833).
September 16	Miscellaneous stores and 10,000 vehicle tyres.	M.O.A. Storage Depot, Rotherwas, Hereford.	RUSSELL, BALDWIN & BRIGHT LTD., (Dept. L), 20 King Street, Hereford. (Tel.: 4366).
September 21	Machine tools and miscellaneous stores.	Technical Stores Depot, Old Dalby, Leics. (Sale at Melton Mowbray).	SHOULER & SON, (Dept. L), 1, Norman Street, Melton Mowbray, Leics. (Tel.: 3081).
September 27-30	Vehicles, motor cycles, earth moving and lifting equipment.	M.O.A. Storage Depot, Ruddington, Notts.	WALKER, WALTON & HANSON, (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 54272).
October 19	Miscellaneous stores.	Northern Command Ordnance, Sub. Depot, Barlow, Nr. Selby, Yorks.	BARTLE & SON, (Dept. L), 50-52 Merrion St., Leeds, 2. (Tel.: 20898).

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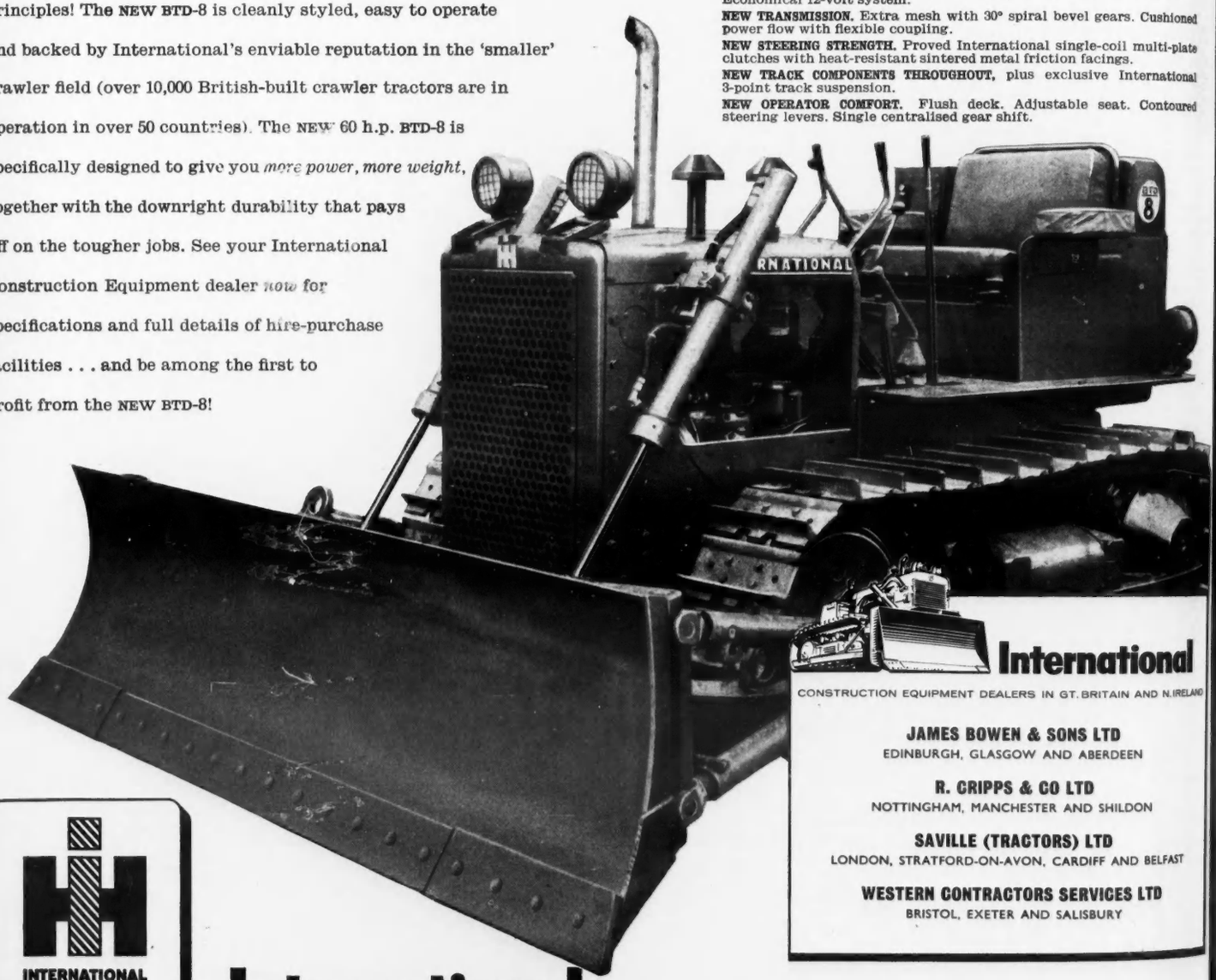

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Sugden, T., Ltd.	75
Sulzer Bros. (London), Ltd.	39
Swain, J. & Son, Ltd.	53
Tangyes, Ltd.	85
Taylor Industrial Clutches	4
Technoexport	43
Titanium Metal & Alloys, Ltd.	77
Town, F. & Sons, Ltd.	8
Twiflex Couplings, Ltd.	35
United States Metallic Packing Co., Ltd.	37
Vickers-Armstrongs (Engineers), Ltd.	62
Vokes, Ltd.	67
Wellington Tube Works, Ltd.	95
Wells, A. C. & Co., Ltd.	20
Werkspoor	76
West Ham Testing Laboratory.	35
West Yorkshire Foundries, Ltd.	83
Wharton Crane & Hoist Co., Ltd.	65
Wheatley Kirk, Price & Co.	109
Wheatley & Whiteley	25
White, S. S. Dental Manufacturing Co. (G.B.), Ltd.	53
Wigglesworth, F. & Co., Ltd.	86
Wood, E. & Co., Ltd.	98-99
Youngs (Lifting Appliances), Ltd.	63

AERASPRAY *Spray Booths*

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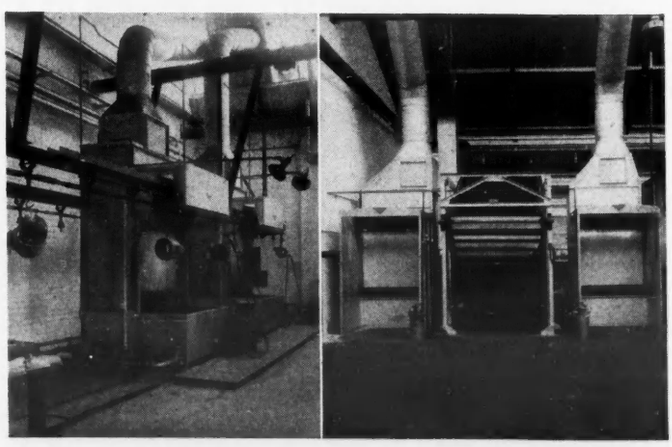

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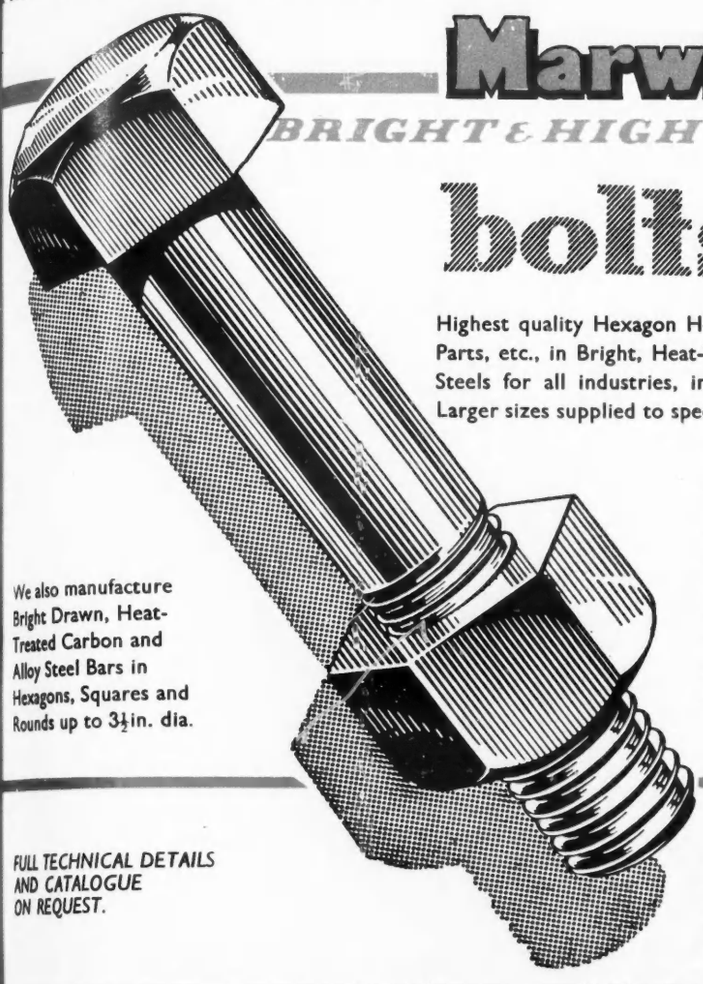

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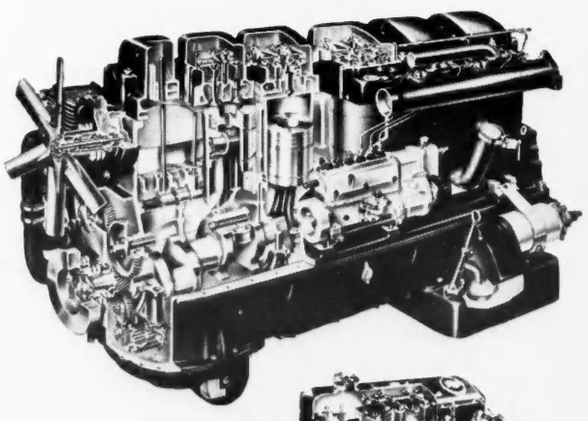

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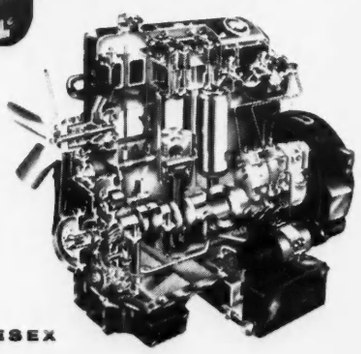

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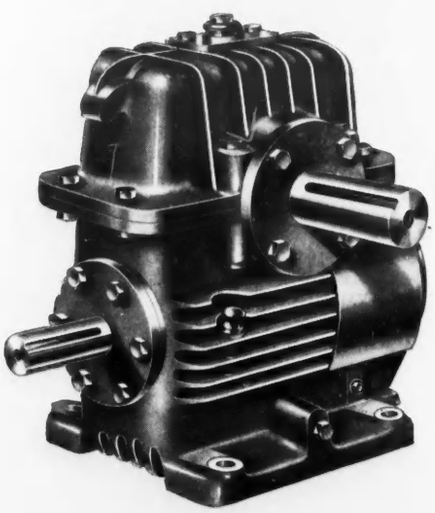

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